

Tackling Micropollutants in Wastewater

Results of the Dutch Innovation and Implementation Program

O3-STEP filter

Pilot results

Manon Bechger - Waternet



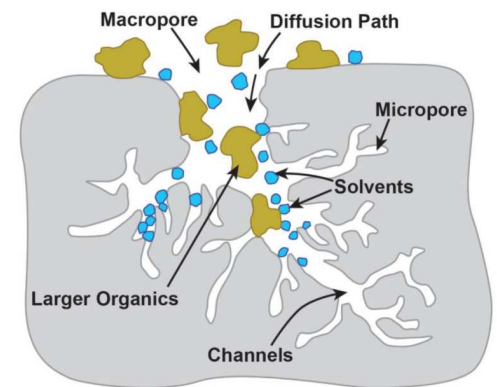
Pilot research O3-STEP

- Pilot O3-STEP filter
- Results pilottest
 - Micropollutants
 - Bromide-bromate
 - Nutrients removal
- CO₂ footprint and costs
- Full-scale O3-STEP on WWTP Horstermeer



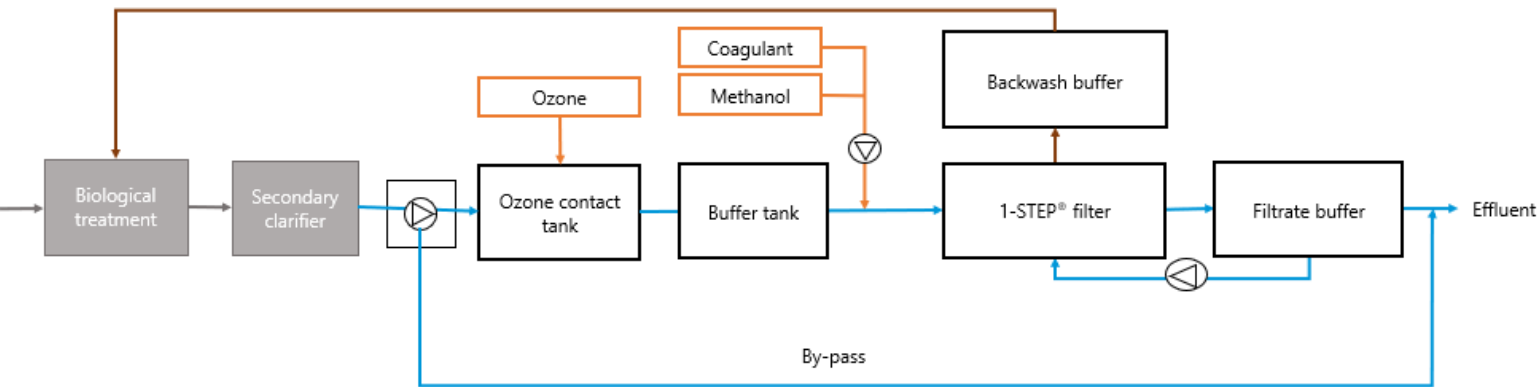
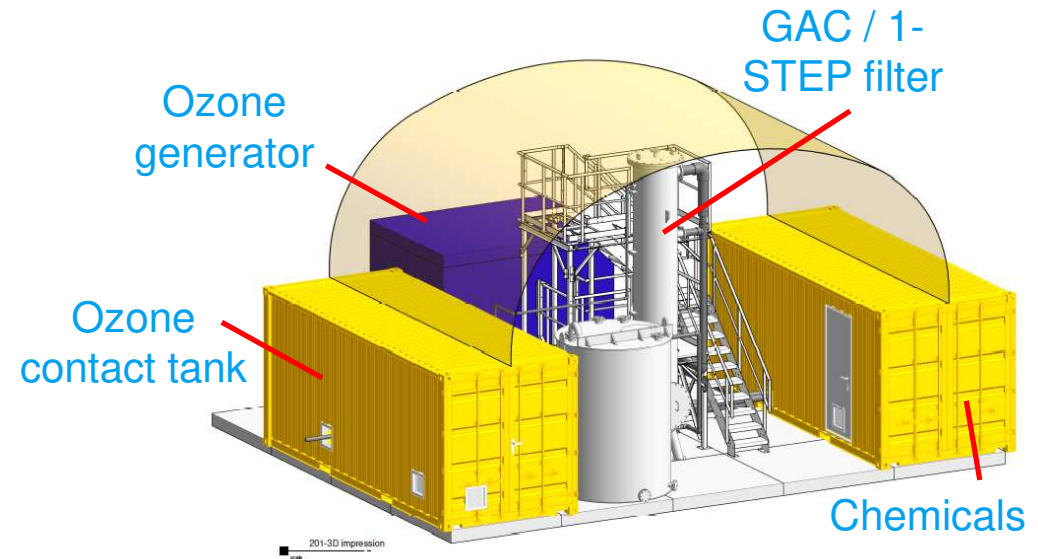
O3-STEP filter

- Combination of ozone en activated carbon filtration
 - **O3** = oxidation with ozone
 - **STEP** = 1-STEP[®] filter – granular activated carbon (GAC) filter
 - Adsorption of micropollutants
 - Removal of nutrients and suspended solids
- Research goals
 - Removal of 80% of the guides substances (7 best)
 - Nutrients and TSS equal to full-scale 1-STEP[®]
 - Lifetime of the GAC; doubling the lifetime compared to stand-alone 1-STEP[®]



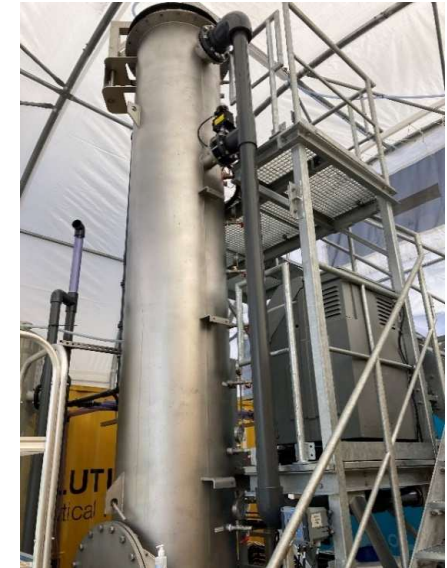
Setup pilot O3-STEP

Pilot test on WWTP Horstermeer
(of waterboard AGV)



Pilot long-term test

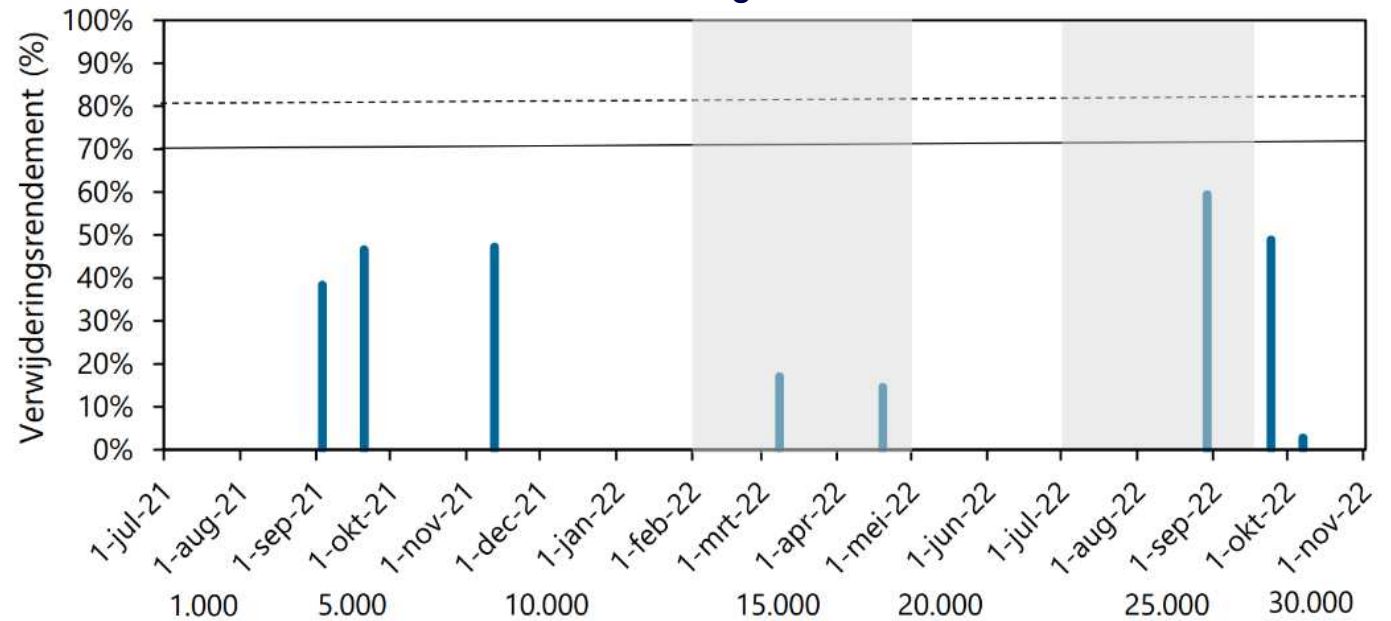
- Start July 2021 – end October 2022
- Flow 3 m³/h
- Ozone dosage: 0,4 g O₃/g DOC
- GAC filter: 17 min EBCT (2,2 m)
- Sampling points:
 - Pilot supply (effluent WWTP)
 - After ozone
 - After GAC filter



Results guide substances

	Average 11 guide substances	Average 7 best guide substances
3 - 4 apr 2021	41%	46%
18-19 apr 2021	73%	78%
11-12 mei 2021	47%	53%
17 - 20 juli 2021	44%	59%
30 aug – 2 sept 2021	21%	43%
19 - 20 sept 2021	34%	45%
16 - 17 nov 2021	31%	47%
15 - 16 jan 2022	46%	58%
6 - 7 mrt 2022	8,2%	17%
19-20 apr 2022	-6,3%	9,1%
14-15 juli 2022	24%	33%
29-30 aug 2022	41%	56%
23-24 sept 2022	36%	49%

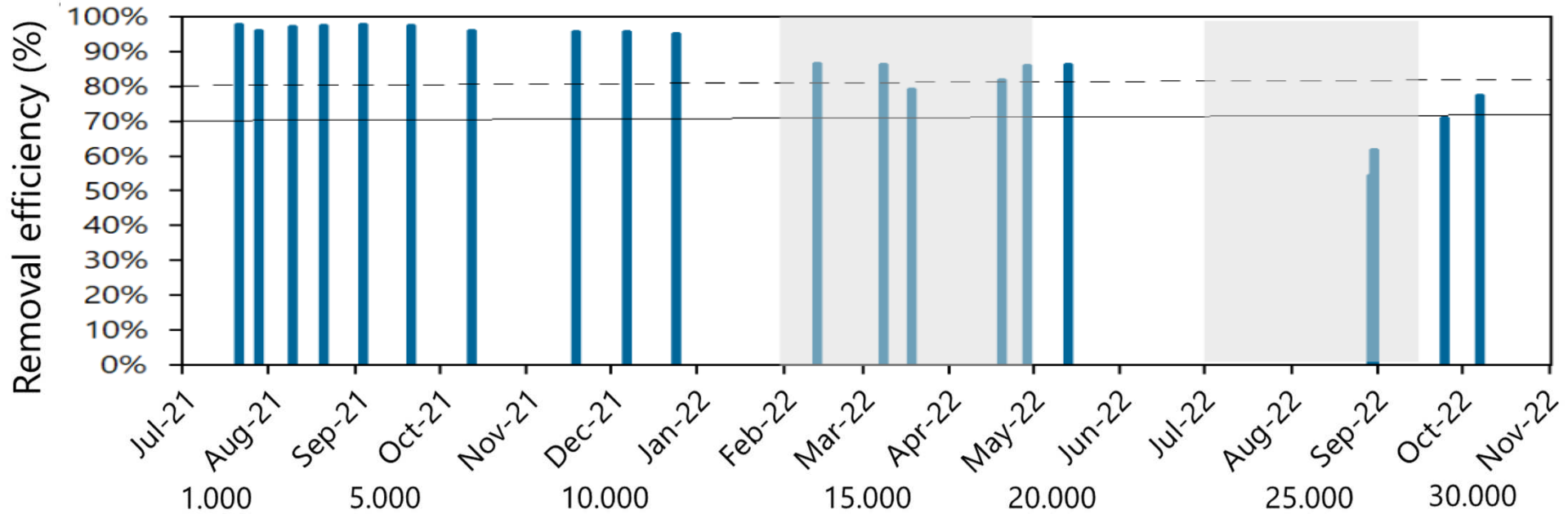
Removal of NL guide substances by WWTP (activated sludge)
7 best of 11 guide substances



- Removal varies a lot

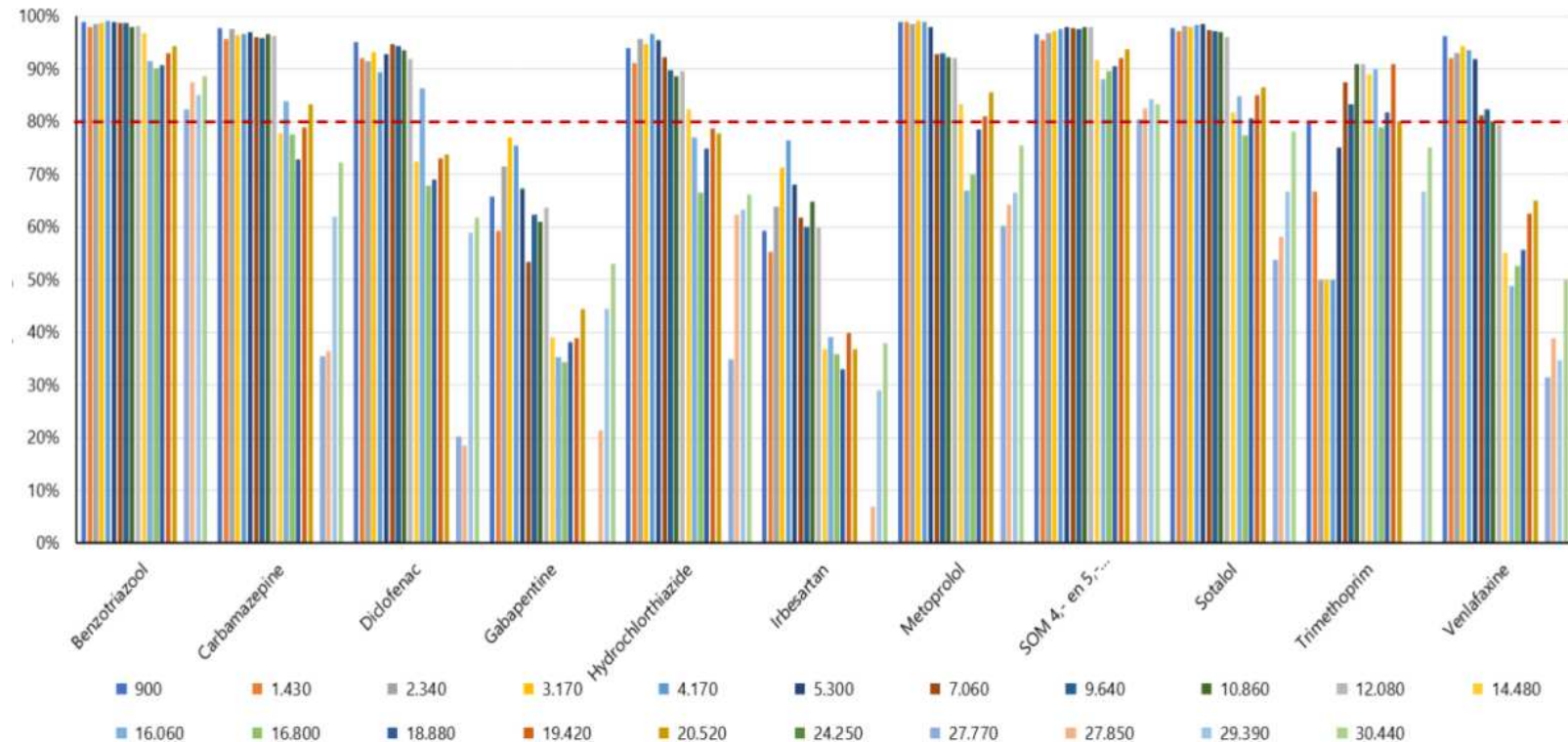
Results guide substances

Removal of NL guide substances by O3-STEP
7 best of 11 guide substances



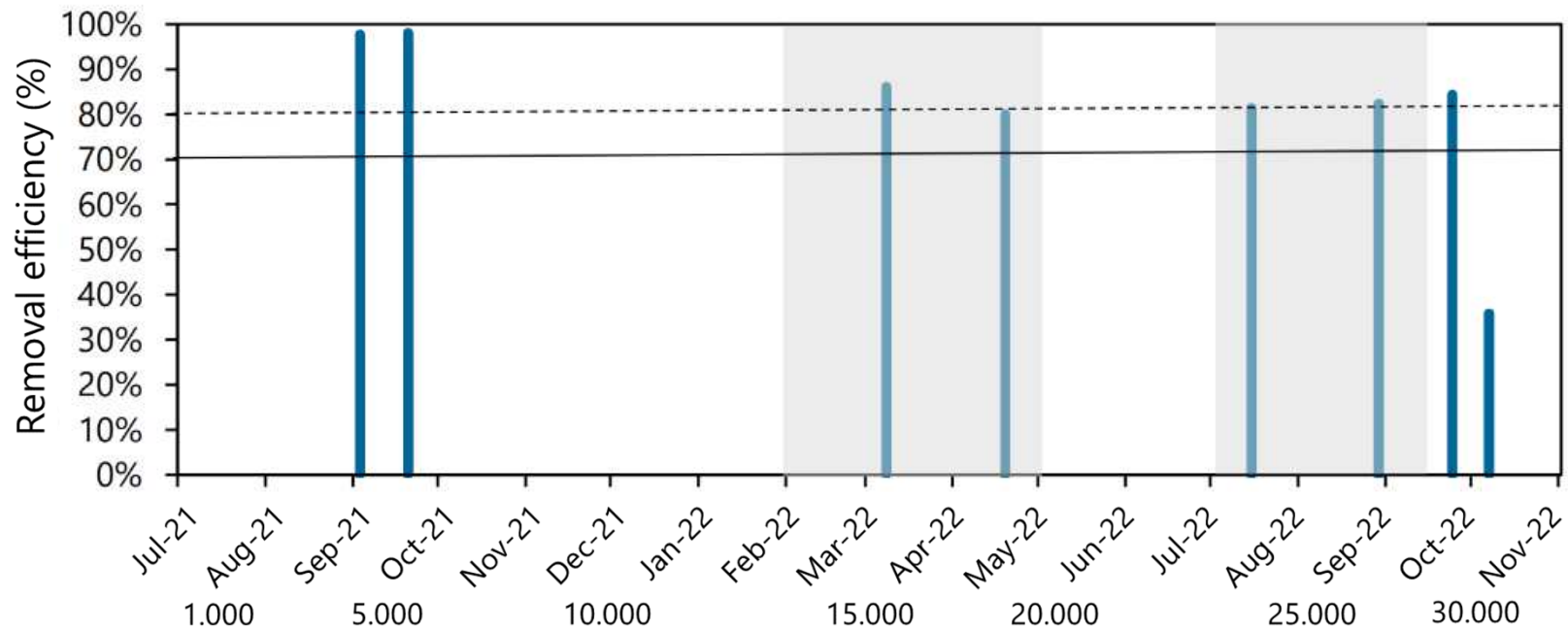
Results guide substances

Removal of NL guide substances by O3-STEP
11 guide substances



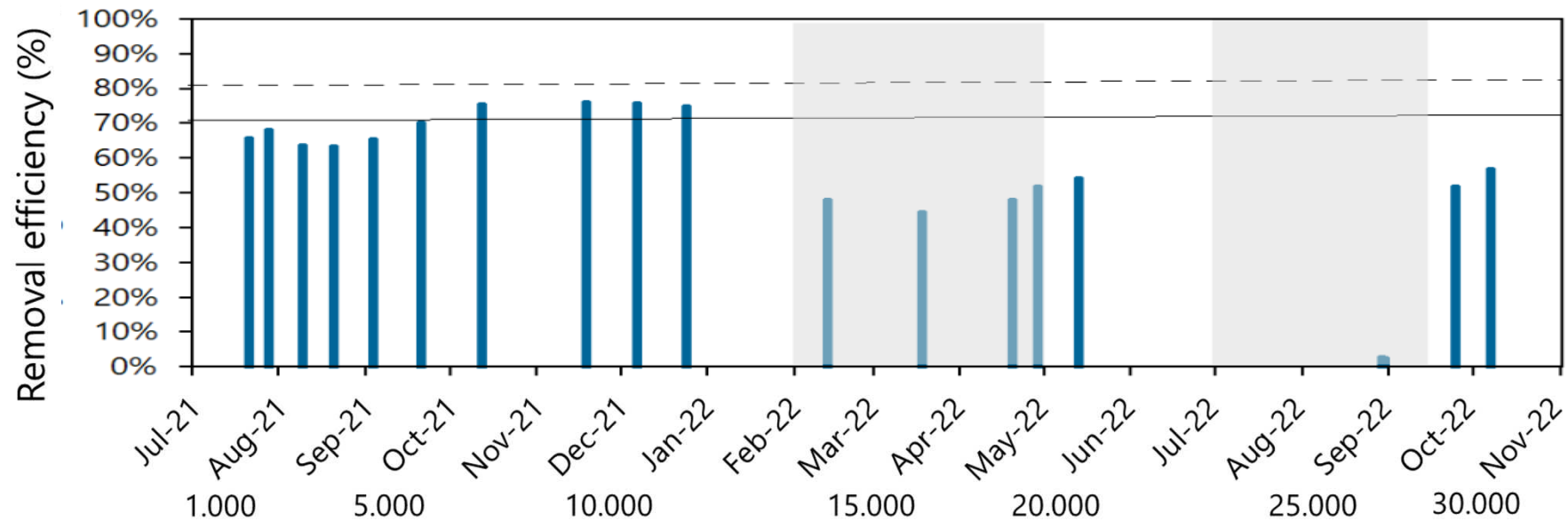
Results guide substances

Removal of NL guide substances by WWTP + O3-STEP
7 best of 11 guide substances



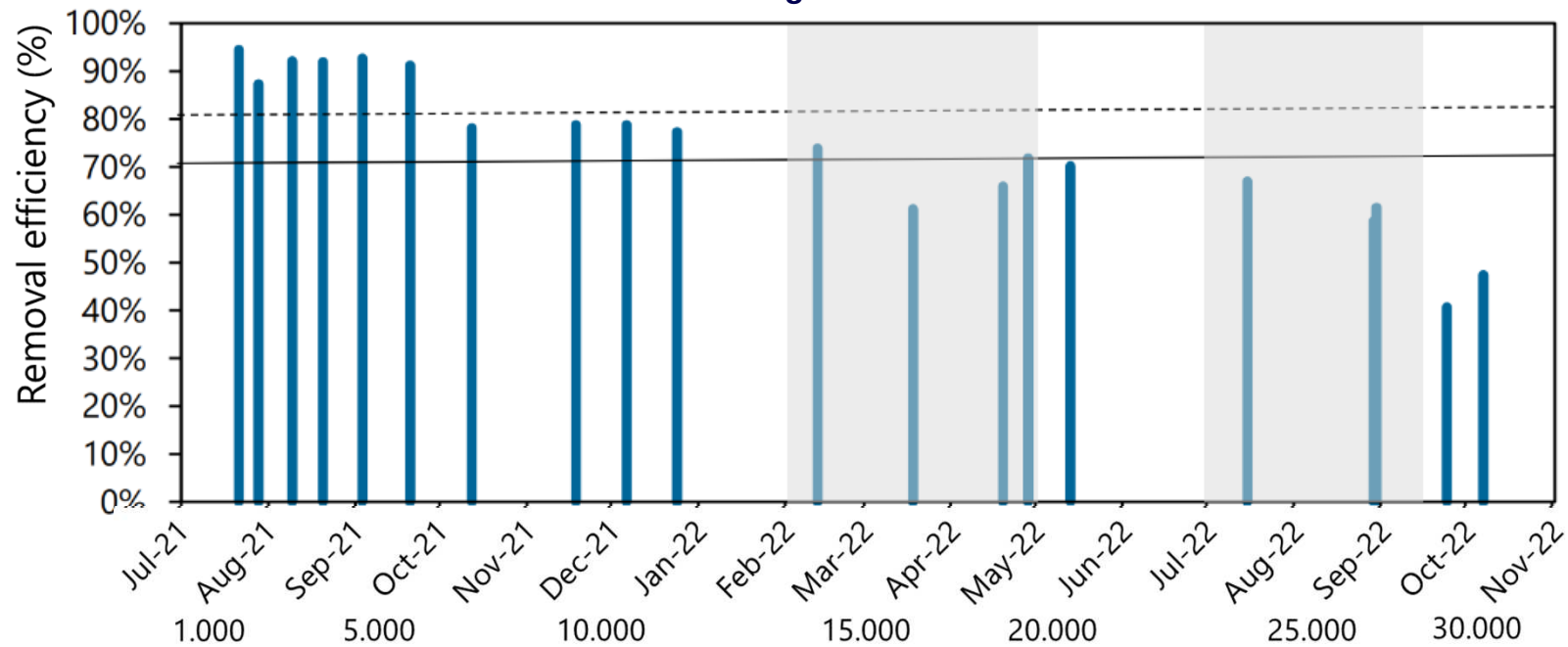
Results guide substances

Removal of NL guide substances by O3
(ozone dosage of 0,4 g O₃/g DOC)
7 best of 11 guide substances



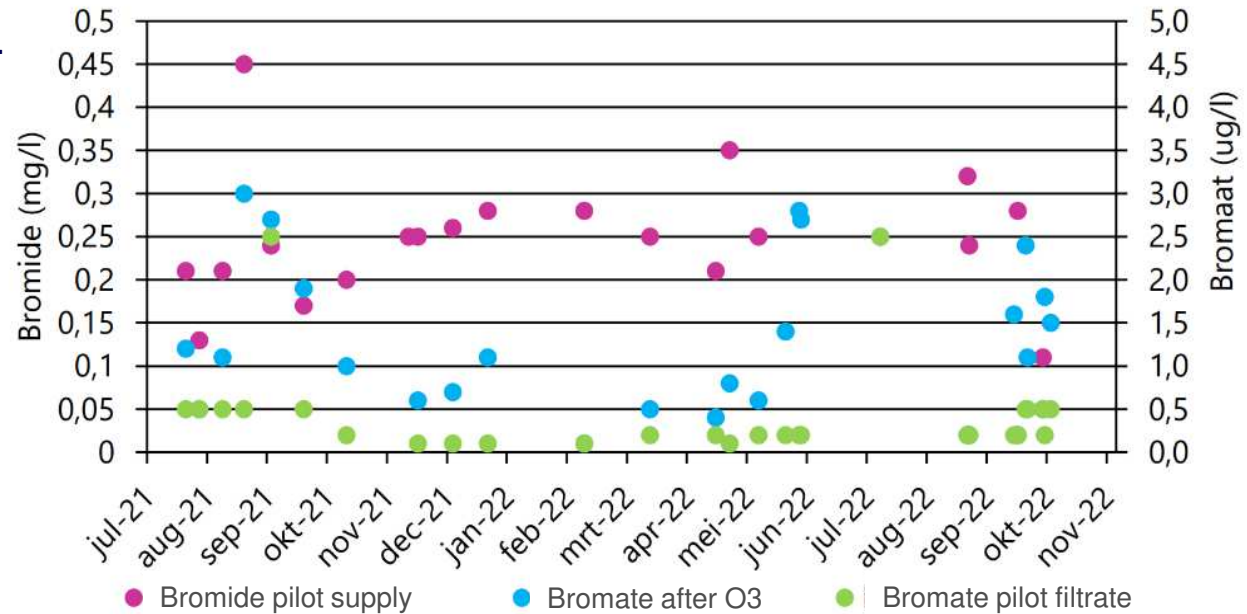
Results guide substances

Removal of NL guide substances by GAC (1-STEP)
7 best of 11 guide substances



Bromide - bromate

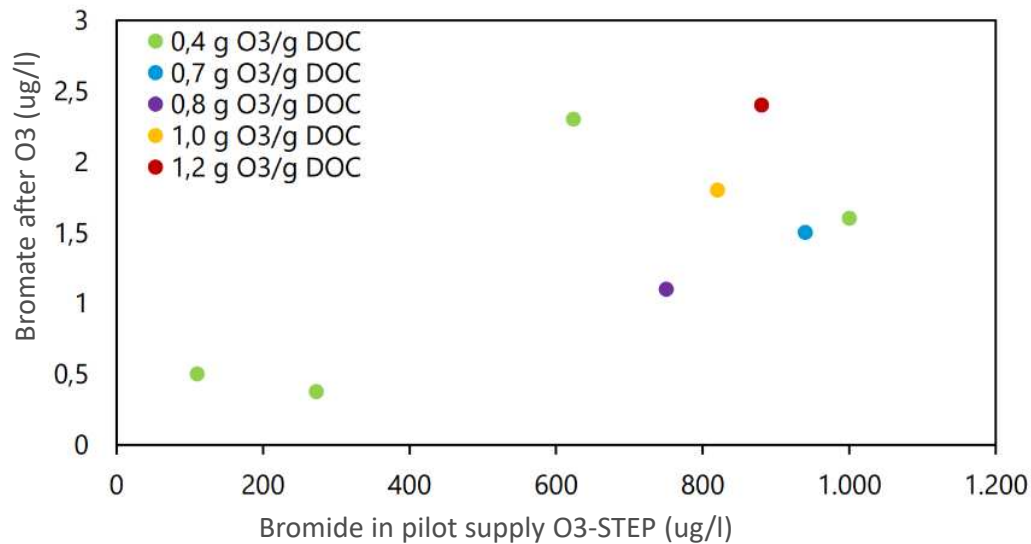
- Surface water quality standard of 1 µg/l for bromate 1 ug/l (RIVM)
- Bromide ~ 250 ug/l
- Bromate after ozone is low
- Removal of bromate by the 1-STEP filter
- What does 1-STEP do with higher bromate concentrations?
 - Bromide spike tests



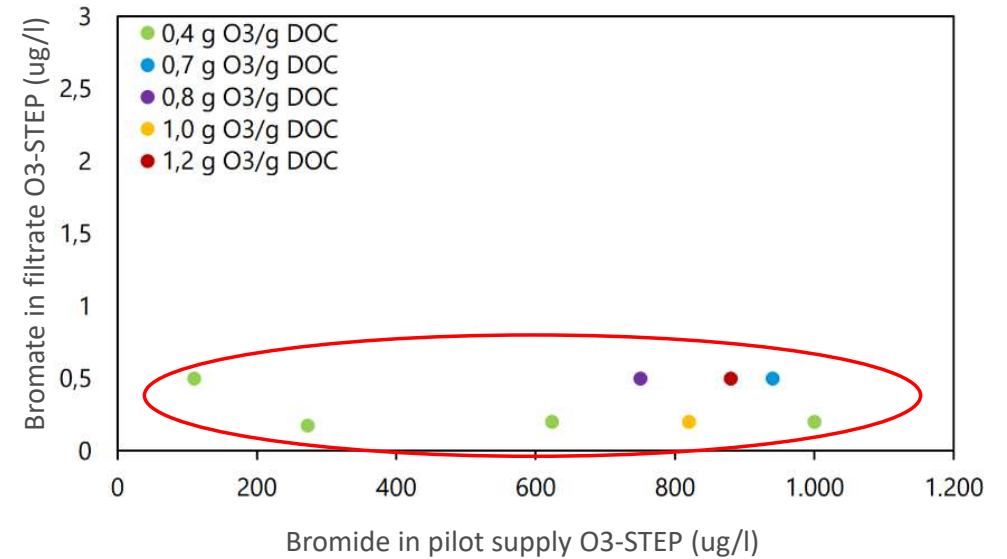
Detection limit reduced from 0,5 to 0,2 µg/l. 2x a peak in detection limit due to a matrix disturbance in the lab of 2.5 ug/

Bromide spike test

Bromate production after ozone



Removal bromate in GAC (1-STEP)



- With high bromide concentration, higher bromate production,
- After 1-STEP bromate < detection limit

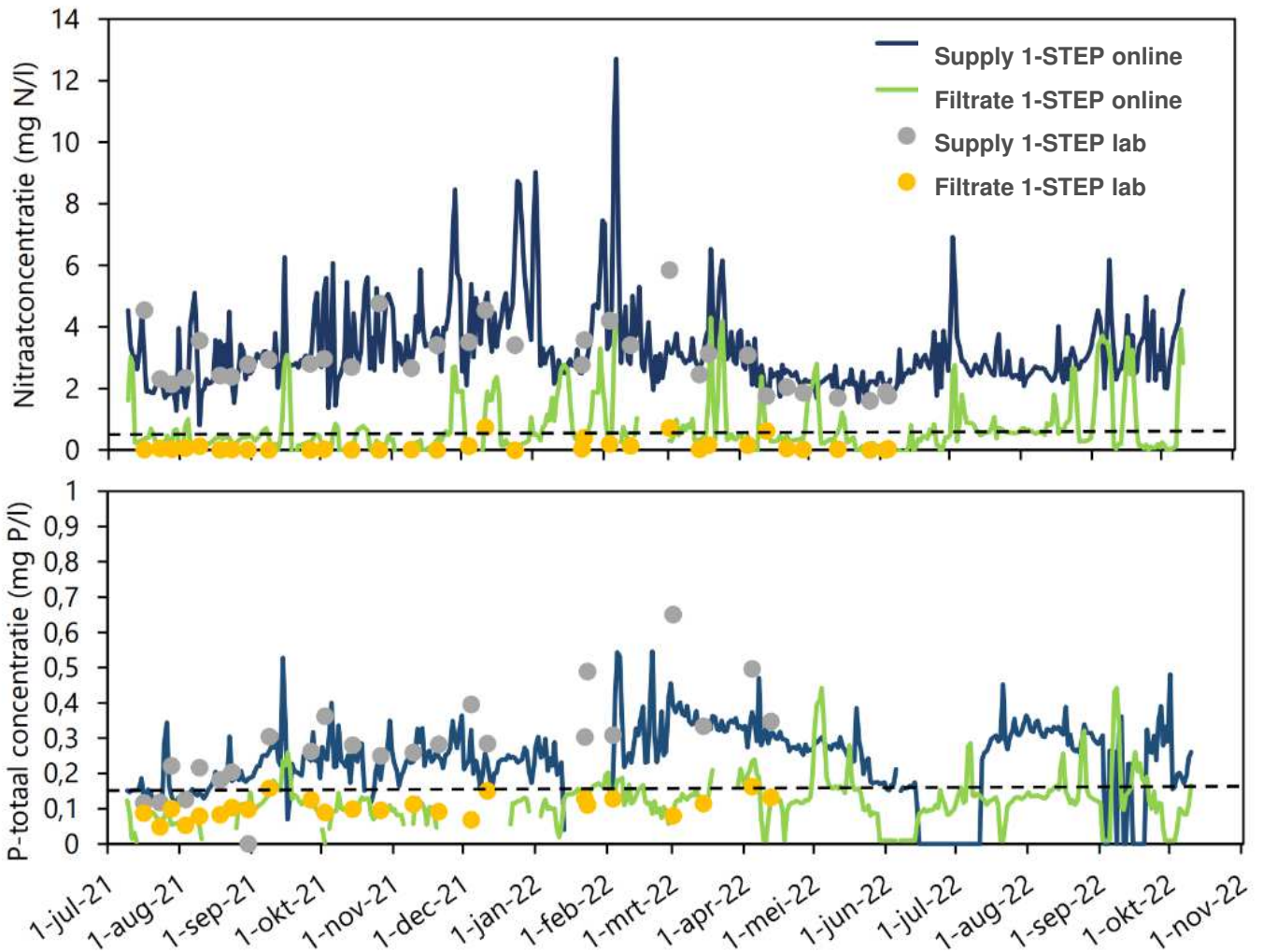
Nutrients O3-STEP

Total nitrogen

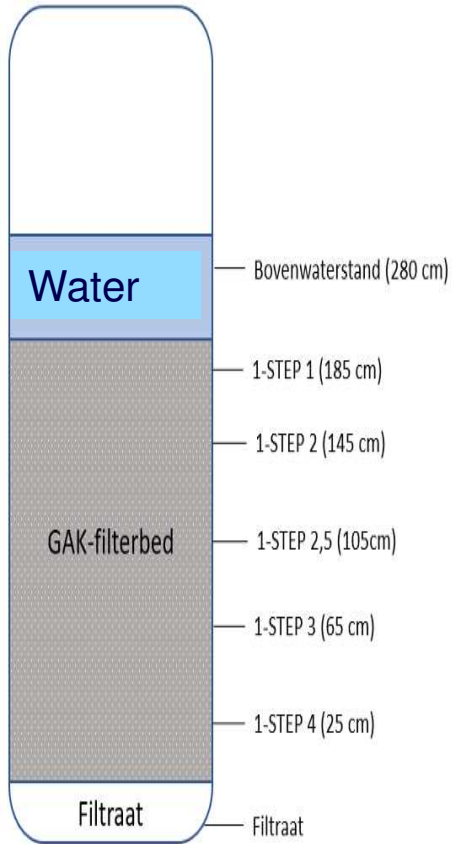
N-total average 2.1 mg/l

Total phosphorus

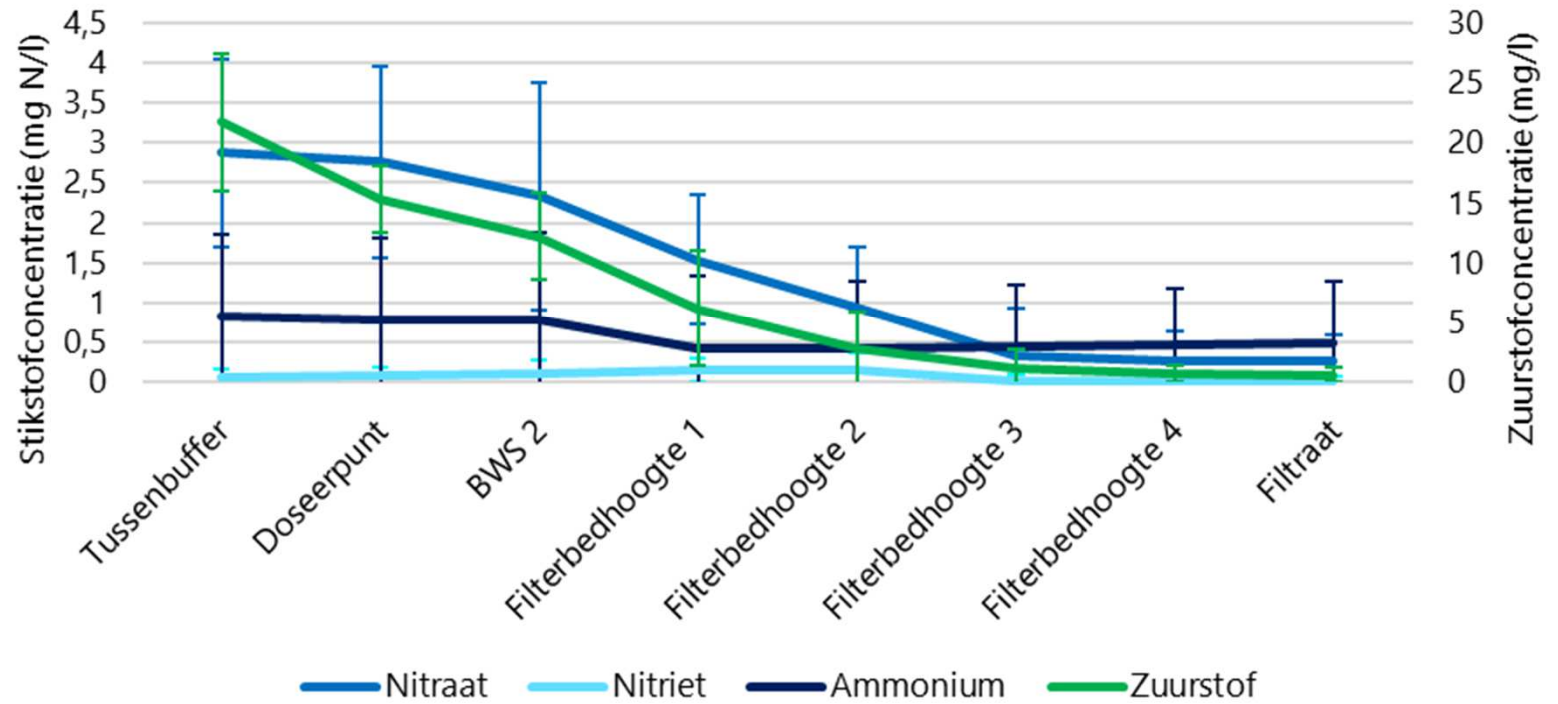
P-total average 0.10 mg/l



Profile O3-STEP

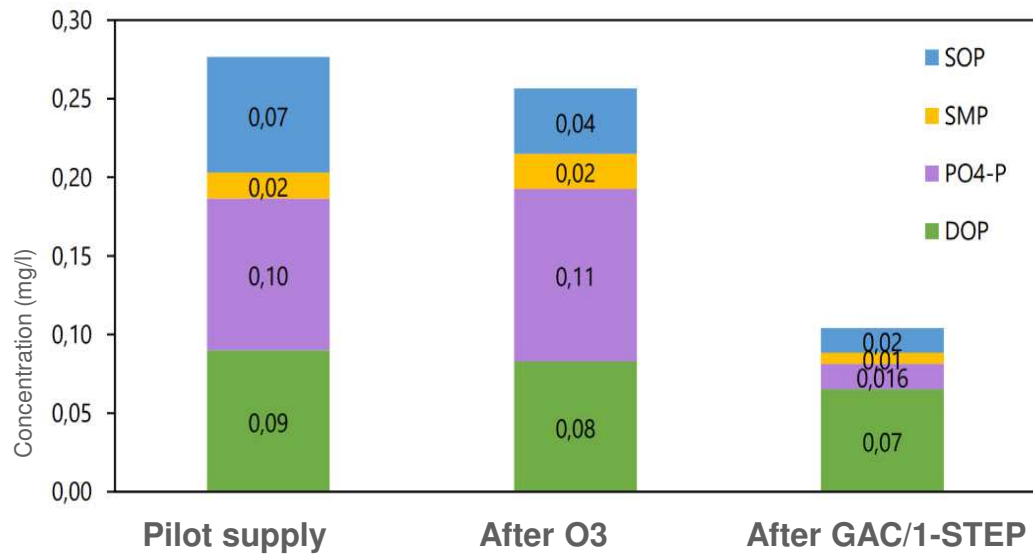


Removal nitrogen and O2 consumption

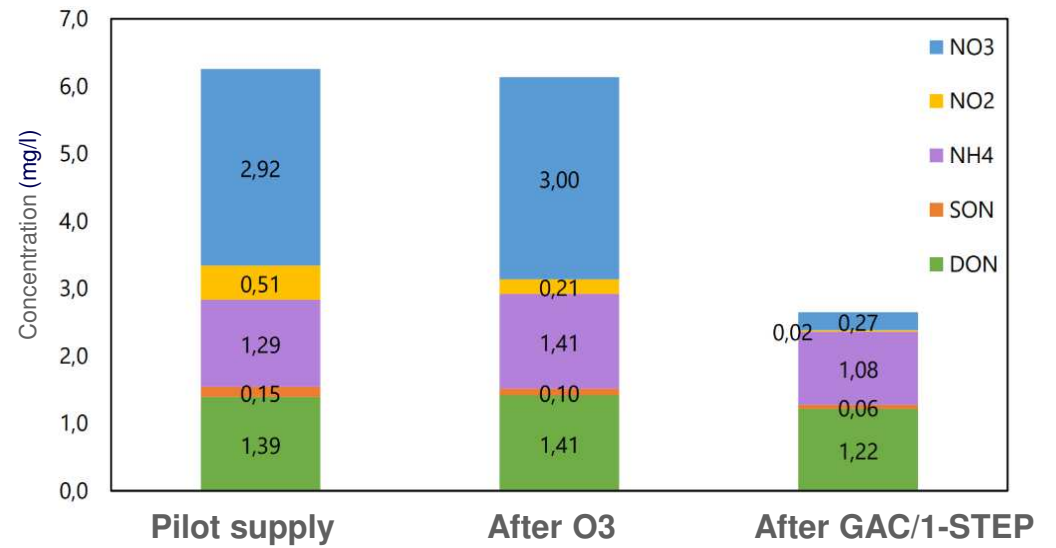


Fractionation

Fractions P (n=15)

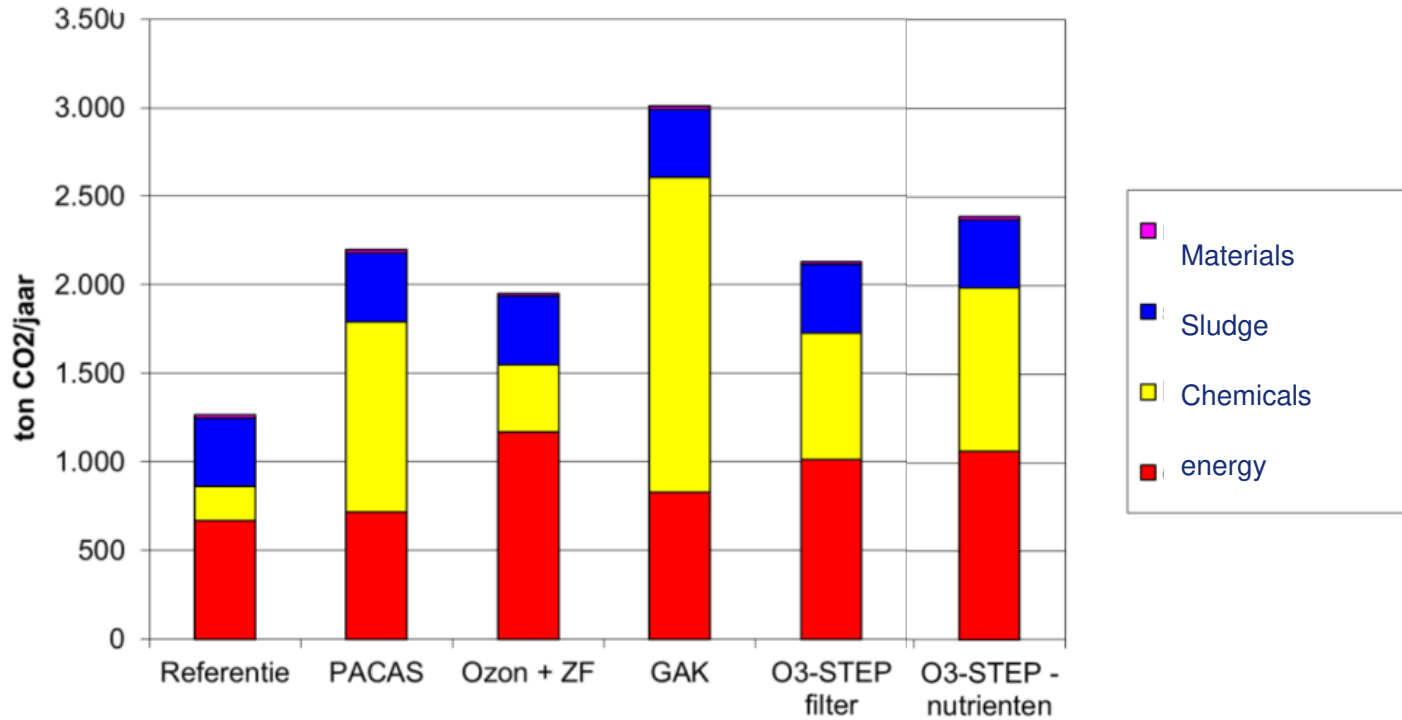


Fractions N (n=5)



CO₂ footprint

CO₂ footprint WWTP incl. removal of micropollutants



- Based on removal of 80%
- EBCT 17 min
- Bedvolumes 35.000
- GAC loss reactivation 15%

Summary Performances

	UNIT	PACAS	Ozone + Sand Filtration	O3-STEP only micropollutants	O3-STEP Micropollutants + nutrients
CO2-footprint ¹	g CO ₂ /m ³	122	128	162	210
Costs ¹	€/m ³	0,05	0,17	0,15	0,17
Removal Efficiency NL guide substances ²	%	70-75%	80-85%	80% ³	80% ³

¹ 1 Per treated m3 wastewater: peak dry weather flow must be treated. **Please note: standardized cost and CO2 levels for 2018;** recalibration of all CO2- and cost levels will take place during the evaluation of the Innovation Program in 2024

² Overall Removal Efficiency of effluent wwtp to influent wwtp (including bypass post treatment) for 7 of 11 guide substances: benzotriazol, carbamazepine, diclofenac, irbesartan, gabapentine, metropolol, hydrochloorthiazide, mixture of 4- en 5-methylbenzotriazol, sotalol, trimethoprim en venlafaxine in every 24h or 48h flow or time proportional sample. The sampling has to take the hydraulic retention time of the wwtp into account.

³ Depending on the regeneration frequency of the activated carbon and the specific ozone dosage, a higher efficiency may be achieved

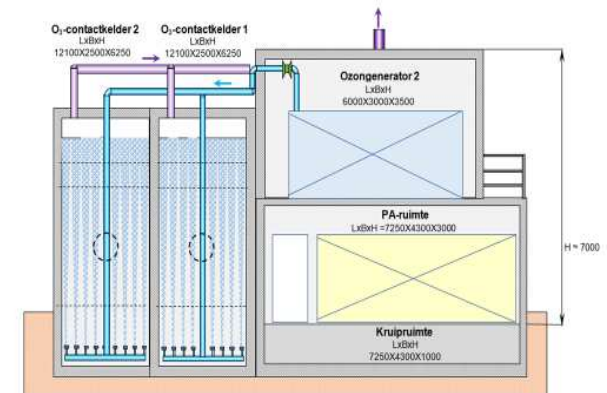
Consequences stricter removal efficiencies Proposal EU Urban Wastewater Treatment Directive (80% in EU in stead of 70% in NL and different guide substances):

- PACAS will have a footprint of 160 g CO₂/m³ and a cost level of € 0,08/m³; no changes for ozone
- **O3-STEP** will have a footprint of 162 / 210 g CO₂/m³ and a cost level of € 0,15 – 0,17/m³

Full-scale O3-STEP

- On WWTP Horstermeer

- Existing full-scale 1-STEP filter (EBCT minimum of 11 minutes)
- New build ozone-installation
- Construction ready January 2024
- 1700 m³/h, 2 streams, 2 generators
- 12 min contact time (at highest flow)
- 0,4 g O₃/g DOC
- Process control online DOC / UV₂₅₄



Construction ozone reactor

Inside the ozone contact tank





Thank you for your attention!

Manon Bechger – Waternet - manon.bechger@waternet.nl

Christa Morgenschweis – Waternet - christa.morgenschweis@waternet.nl

Veerle Luimstra – Witteveen+Bos – veerle.luimstra@witteveenbos.com



stowa

Tackling Micropollutants in Wastewater
Results of the Dutch Innovation and Implementation Program



Rijkswaterstaat
Ministry of Infrastructure
and Water Management

November 8 and 9 2023
Aquatech Amsterdam