

# Improving the removal efficiency of micropollutants using a combination of ozonation and GAC filtration

Results of a pilot study

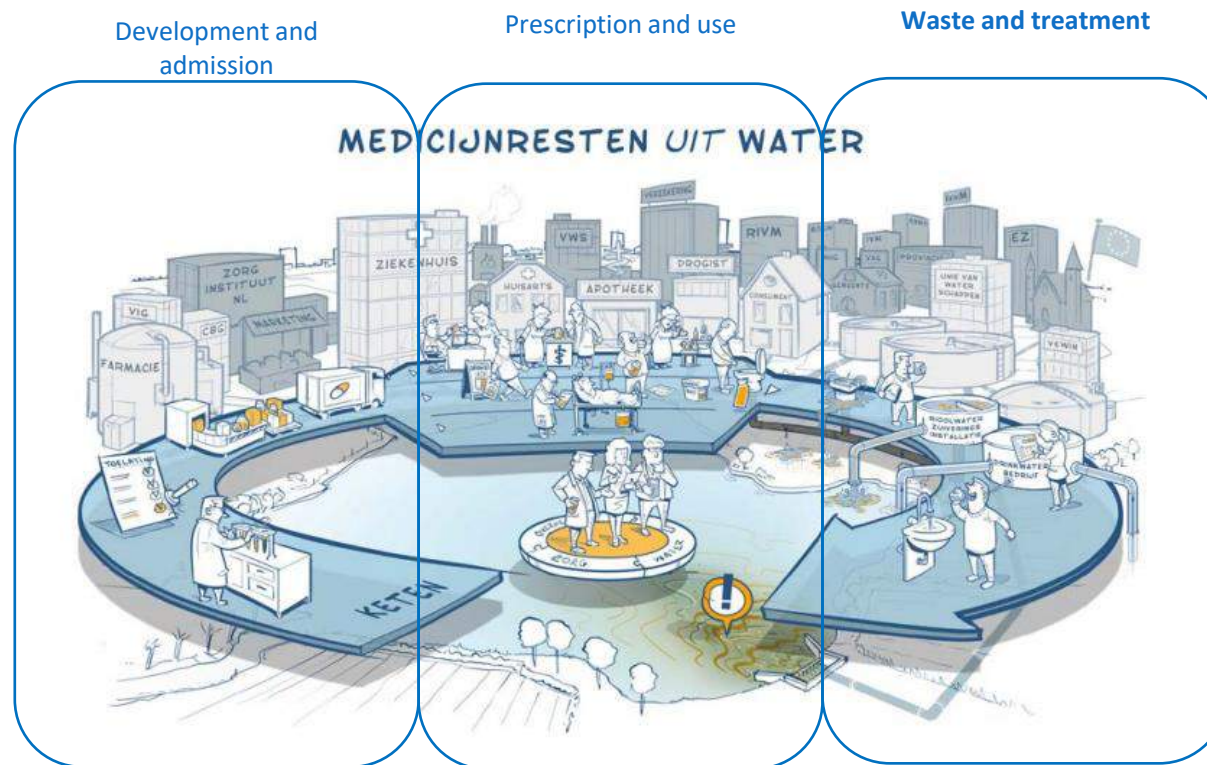
using effluent of a wastewater treatment plant in The Netherlands

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# Content

- Background: from 1-STEP<sup>®</sup> to O3-STEP<sup>®</sup>
- Pilot research methods
- Results of the O3-STEP pilot
- Conclusions
- Further research

# Dutch program for reduction of micropollutants in water



“Removal of micropollutants with a communal approach”

# The innovation programme

- Several pilot studies
  - (Membrane) filtration
  - (Activated carbon) adsorption
  - Ozonation
  - Combinations of above
- Additional challenges
  - Stricter directive on nutrient removal (P and N)
  - New bromate norm in the Netherlands (Summer 2022)
    - **1 µg/L BrO<sub>3</sub><sup>-</sup> (surface waters)**



# From 1-STEP<sup>®</sup> to O3-STEP<sup>®</sup>

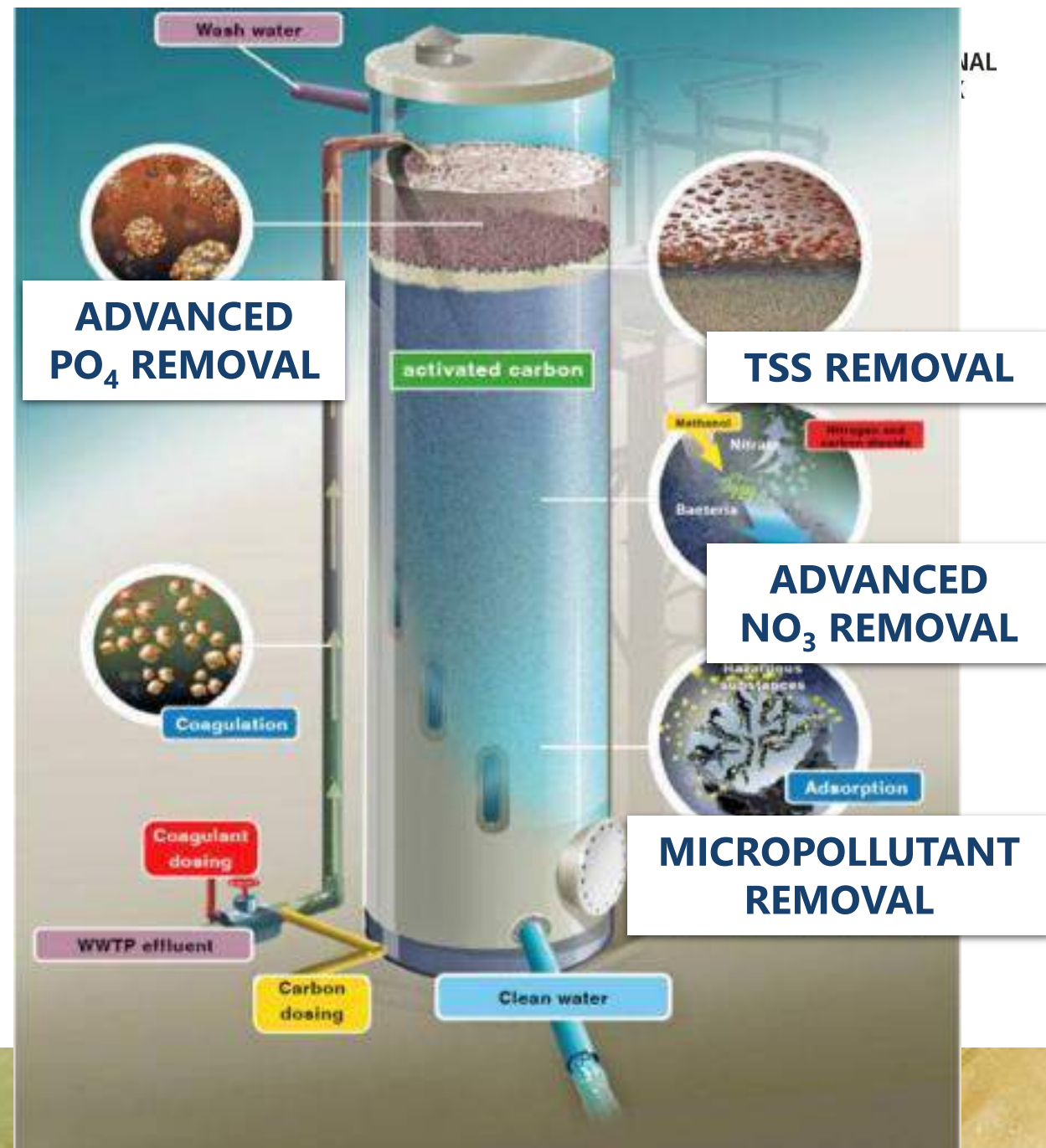
- Addition of O<sub>3</sub> to a successful denitrifying GAC-filter:
- effluent polishing + removal of OMPs



# 1-STEP mechanisms

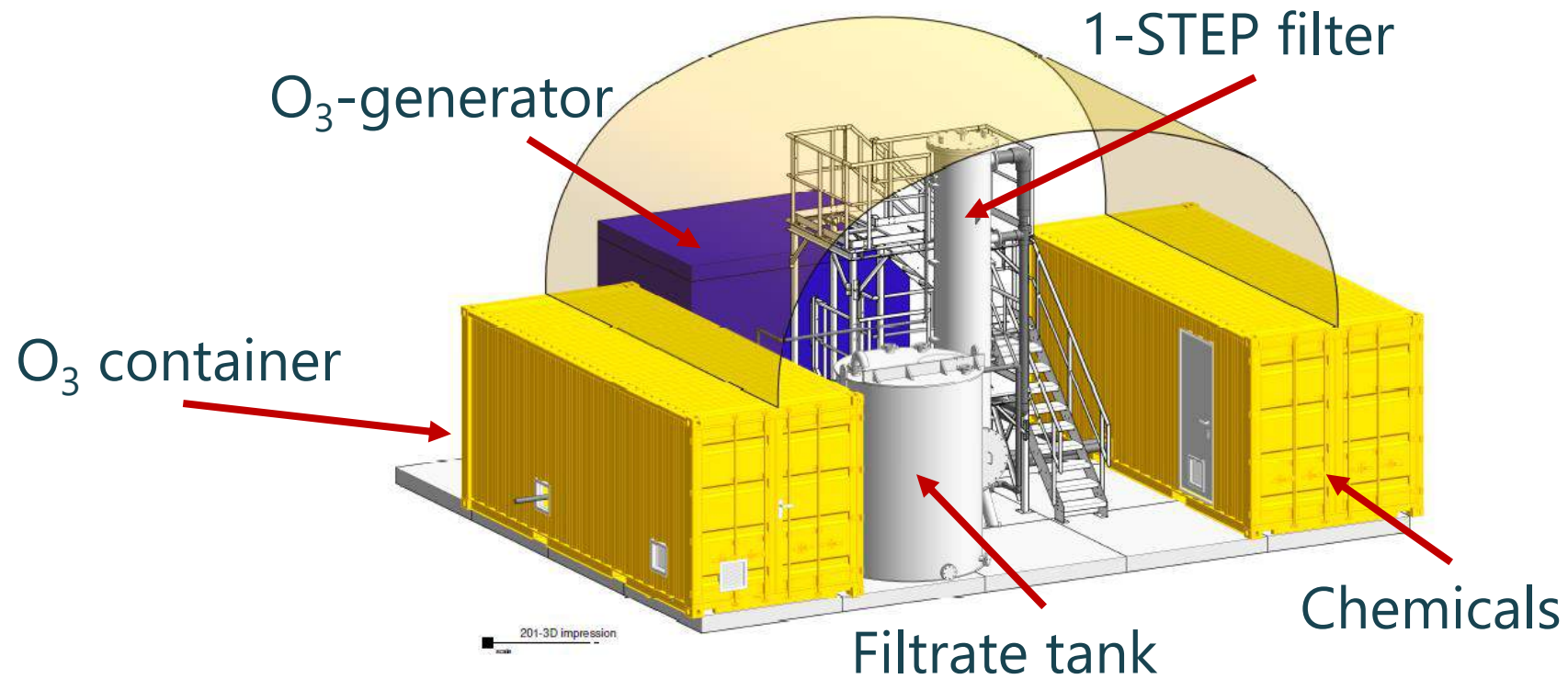
1 Step Total Effluent Polishing filter

4 processes  
in 1 filter unit





# O<sub>3</sub>-STEP pilot installation

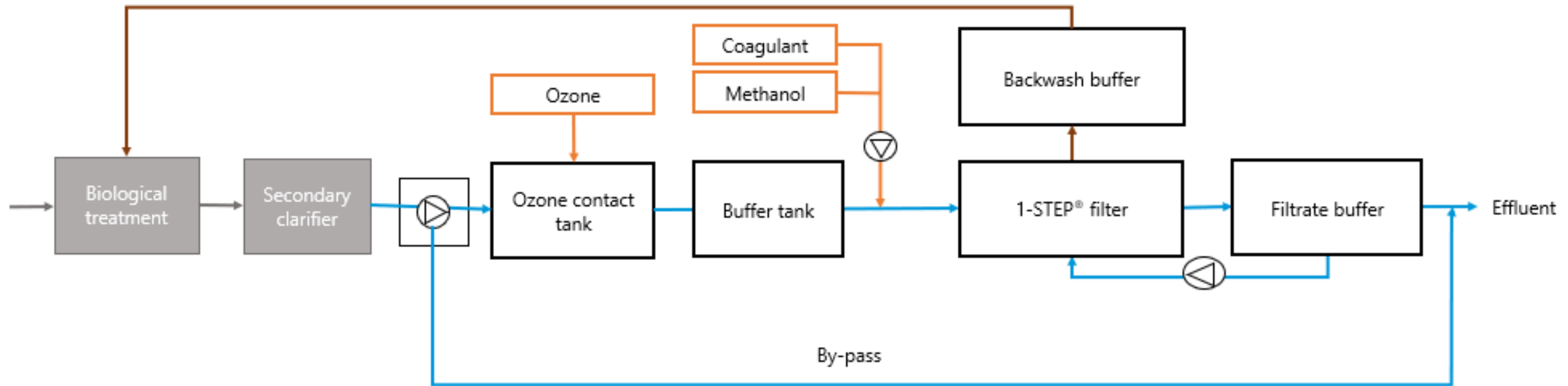


# Research goals

- Increase the life-time of the activated carbon filter
  - Improves cost-effectiveness and sustainability
- >80% removal of micropollutants
  - 7/11 indicator substances (Dutch guidelines)
  - Target wider range of micropollutants
- No negative effect on nutrients/TSS removal
  - At least equal to standalone 1-STEP<sup>®</sup> filter



# Process flow diagram



# Parameters long-term test

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<b>Influent ozone installation</b>	5 m <sup>3</sup> /h
<b>Fixed ozone dosage</b>	0.4 g O <sub>3</sub> /g DOC
<b>Contact time ozone contactor</b>	25 min
<b>1-STEP filter influent</b>	3 m <sup>3</sup> /h
<b>Empty bed contact time (EBCT)</b>	17 min
<b>Bed volumes after 1 year</b>	ca. 29,000 n

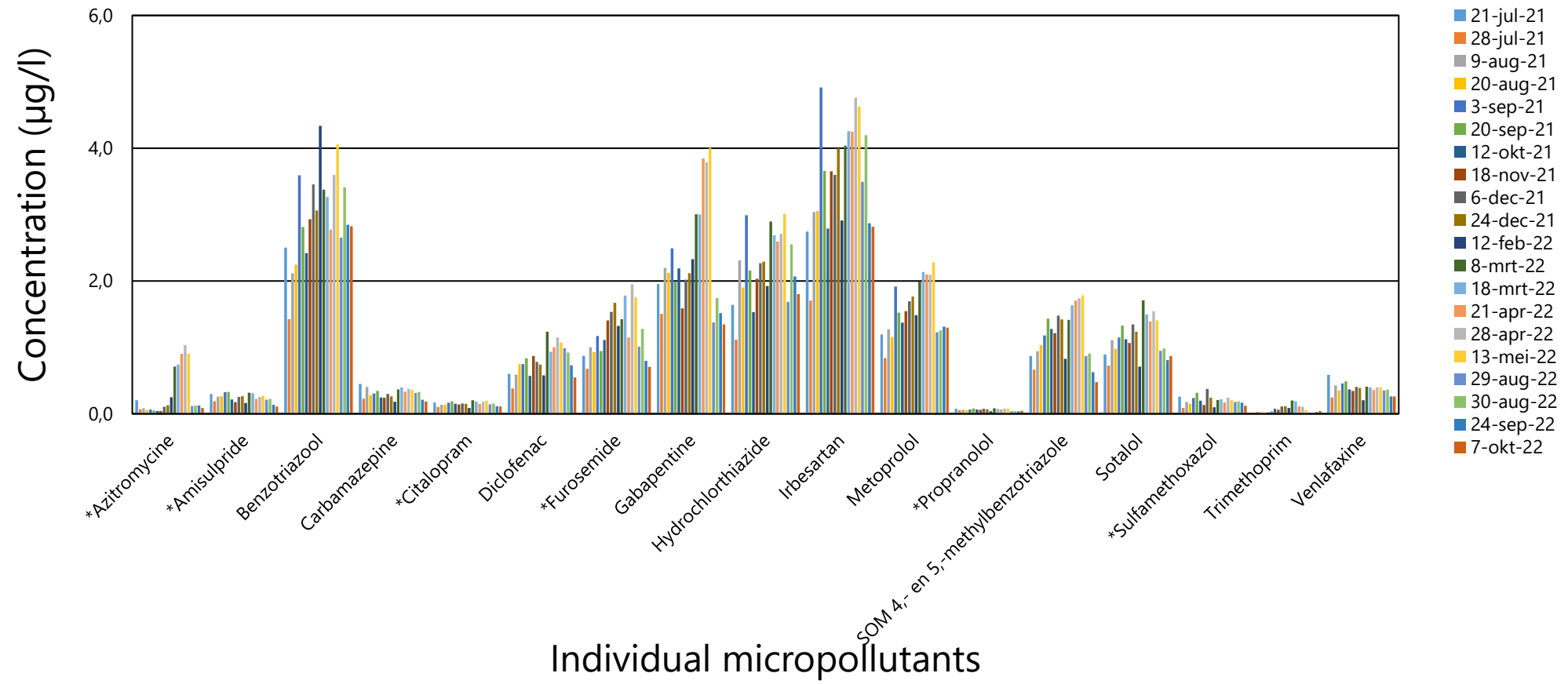
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# Sampling methods

- The pilot lasted ~1.5 years
- Analyzed every 2 weeks
  - Micropollutants (indicator substances)
  - N, P, TSS, DOC
  - Bromate
- Analyzed every two months
  - Ecotoxicology
  - PFAS
  - *E. coli* & enterococci



# Concentrations in feed water of pilot

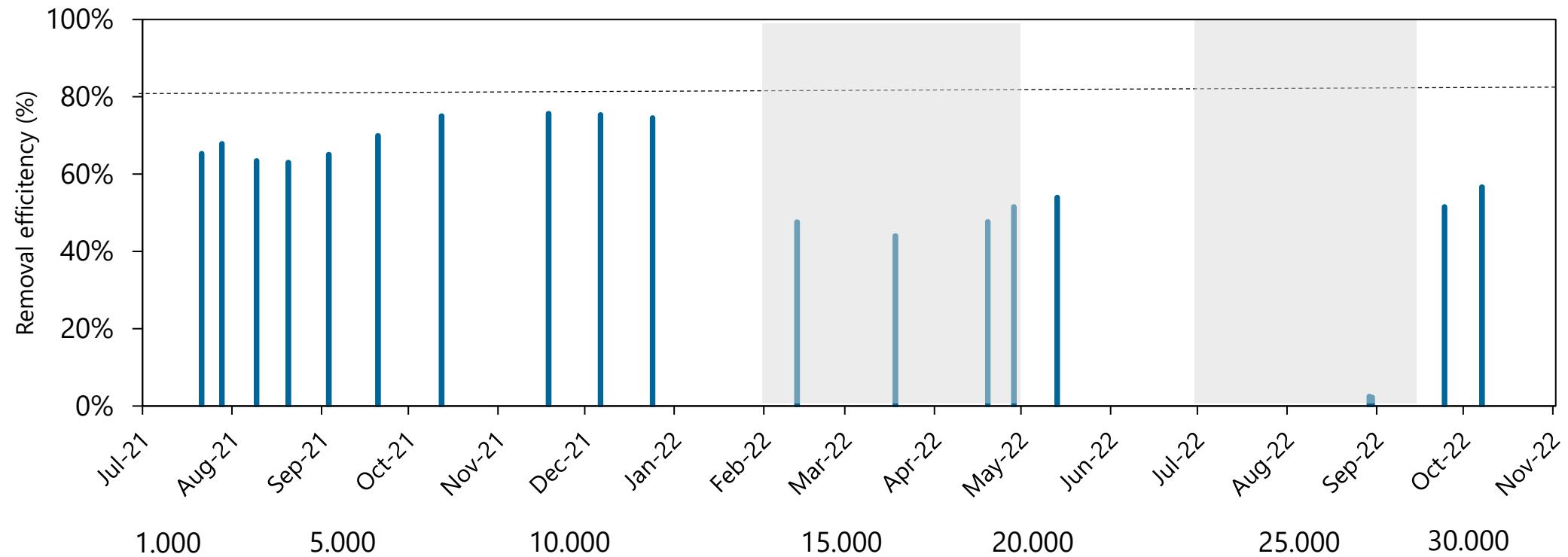


# Results of the O3-STEP filter pilot

- Nutrient and TSS removal similar to standalone 1-STEP filter
- >80% removal of indicator substances
- Increased lifetime of GAC
  - From 15,000 to (predicted) >35,000 bedvolumes

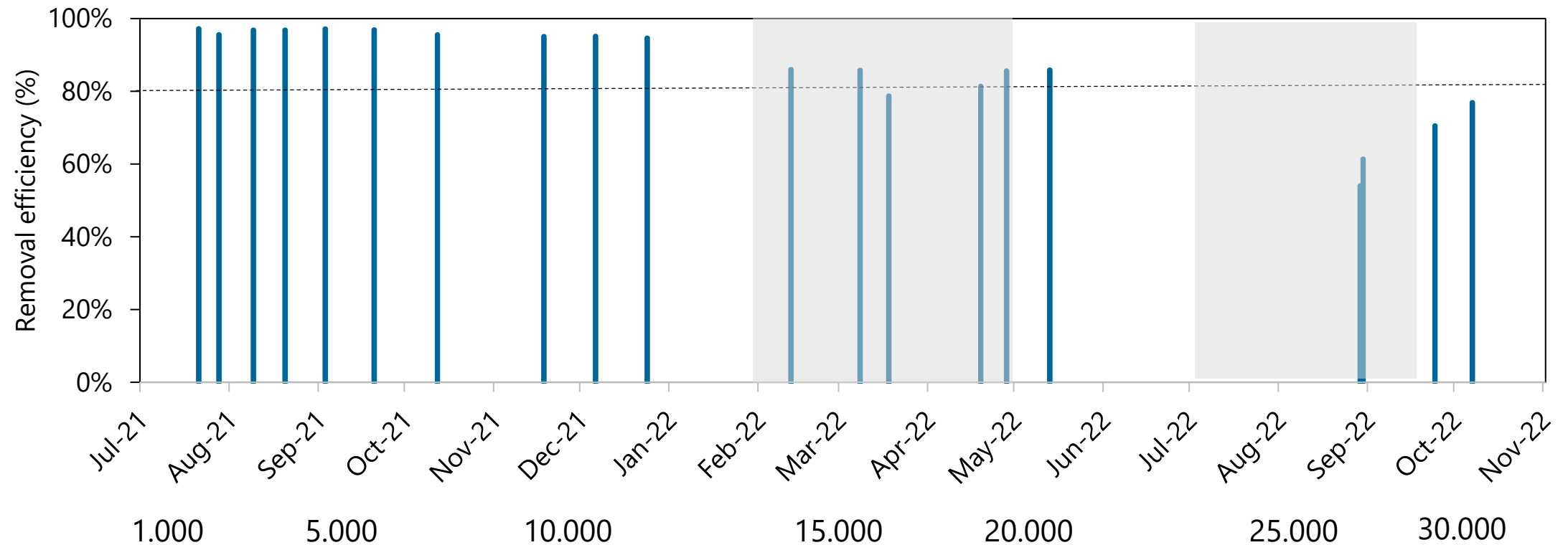


# Micropollutant removal after ozonation

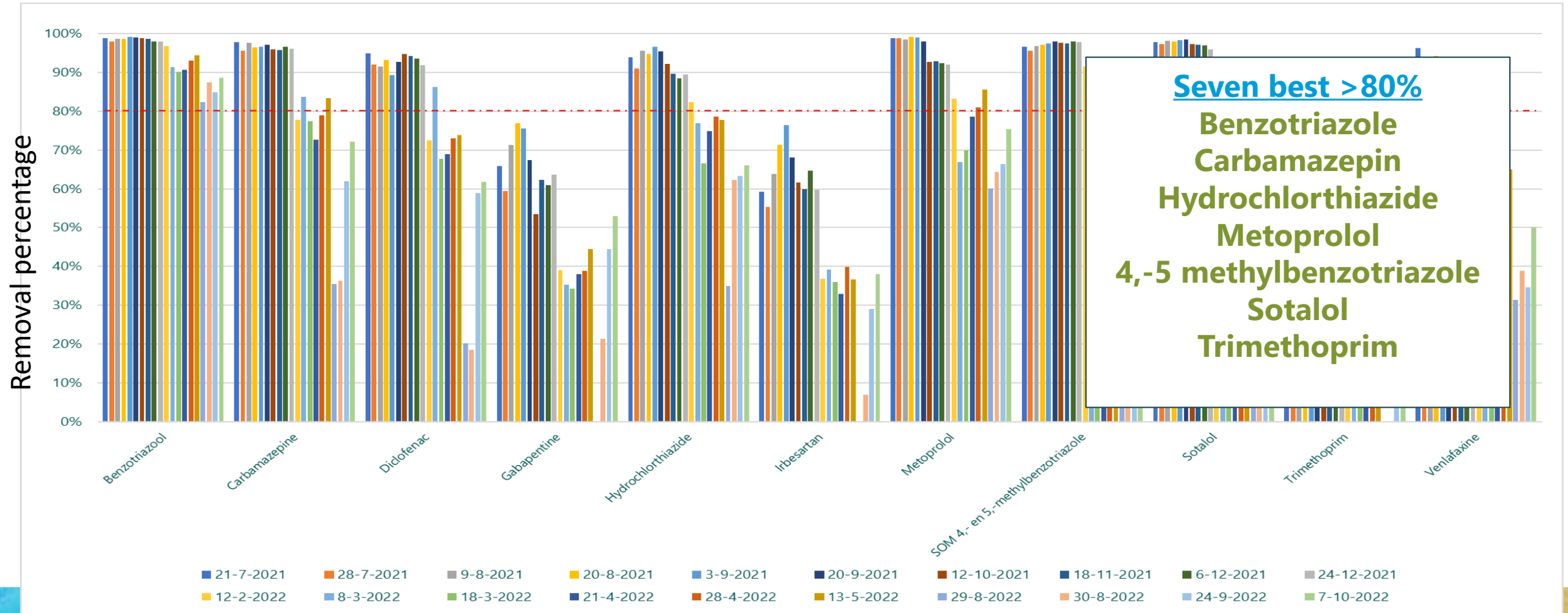




# Micropollutant removal after O3-STEP pilot

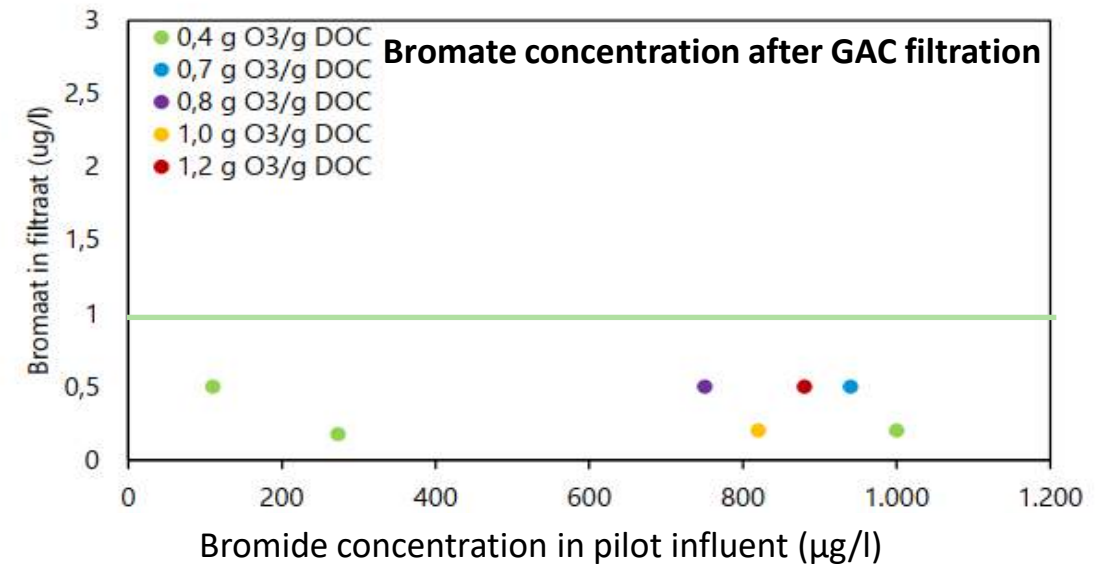
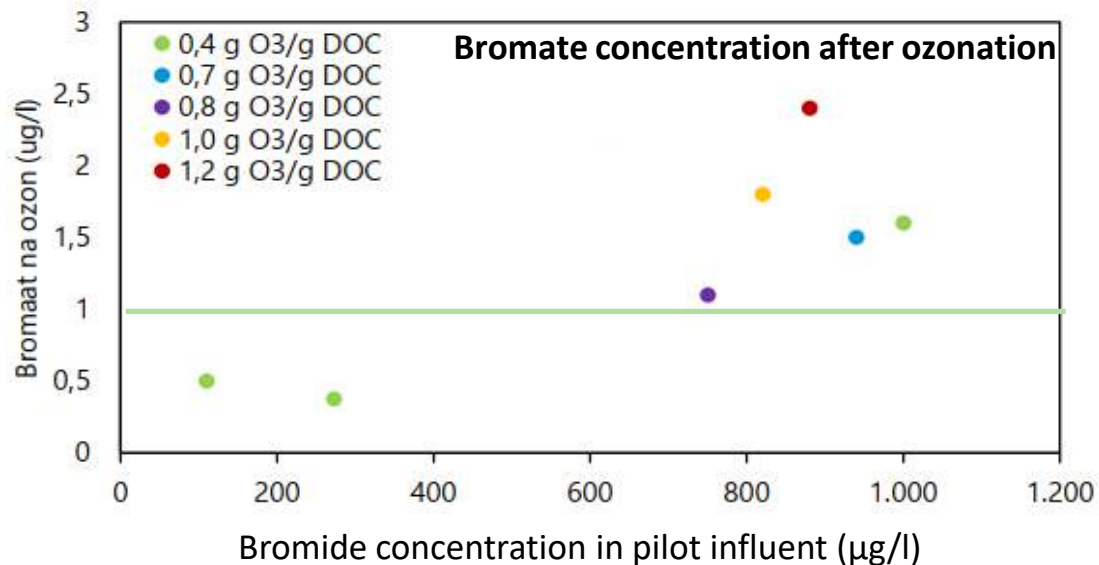


# Micropollutant removal by O3-STEP pilot



# 1-STEP removes transformation products

- Bromate is formed due to ozonation of bromide ( $\text{Br}^-$ )
  - Mild effect despite high bromide and  $\text{O}_3$  concentrations
  - Concentration of bromate decreases in 1-STEP filter
  - Possibly linked to denitrification
- The ecotoxicology is reduced significantly in the 1-STEP filter





# Conclusions

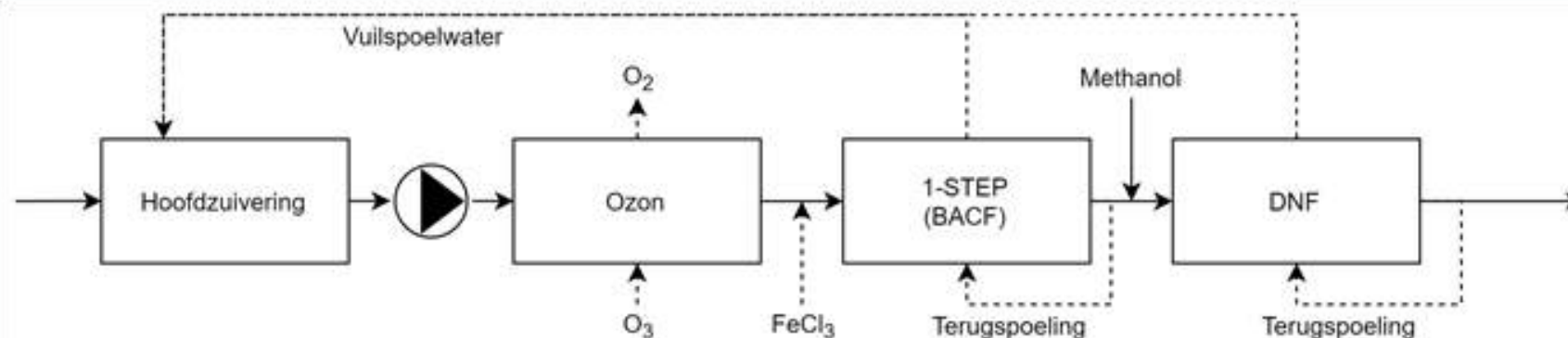
- O3-STEP filter effectively removes
  - nutrients
  - TSS
  - wide range of micropollutants
- Compact solution for an additional treatment step
- Extended carbon lifetime due to ozonation
  - less reactivation: lower costs, more sustainable
- Ozonation byproducts are removed by GAC filter
  - bromate reduced to  $<1.0 \mu\text{g/l}$
  - win-win for both technologies
- Pilot study proved success of combining four processes
  - Several future full-scale O3-STEP filters (some already under construction)
- Further optimization ongoing

# Further optimization of O3-STEP

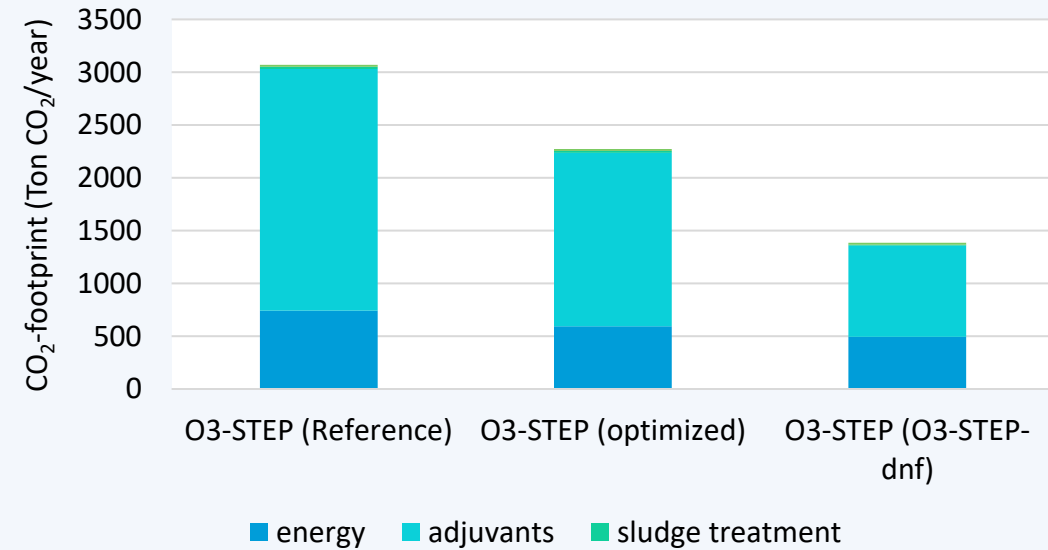
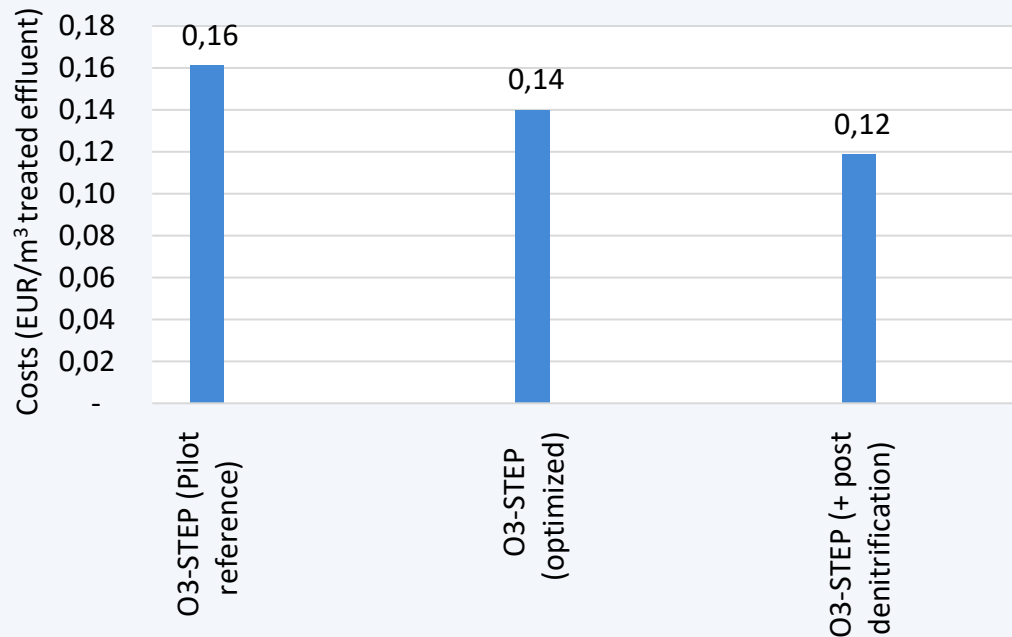
- Sustainable design and operation of the O3-STEP filter
  - lowering ozone ( $\sim 0.2$  g O<sub>3</sub>/g DOC) input and innovations in reactor design
  - lower methanol dosage for denitrification
- Goal: Increasing the lifetime of the activated carbon to >10 years

# Two optimizations

	O3-STEP (Pilot reference)	O3-STEP (Optimized)	O3-STEP (Post-denitrification)
Ozone (g O <sub>3</sub> /g DOC)	0.4 – 0.5	0.25 – 0.35	0.15 – 0.25
Oxygen in GAC- influent (mg/l)	20	7	0
Lifetime of GAC (bv)	35,000	47,000	800,000



# Costs and CO<sub>2</sub>-footprint





## Improving the removal efficiency of micropollutants using a combination of ozonation and GAC filtration

Results of a pilot study using effluent of a wastewater treatment plant in The Netherlands as a part of the IPMV-programme

THANK YOU FOR YOUR ATTENTION



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