

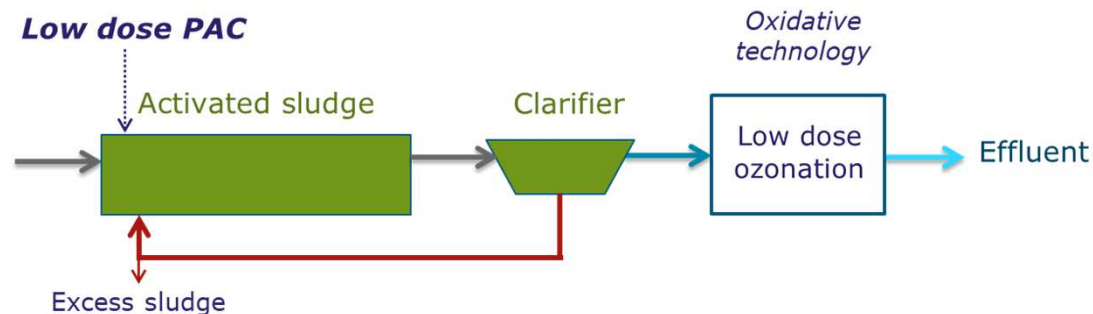
# PAC-O<sub>3</sub> pilot

*Aquatech-Amsterdam*

Laura Piai

9 November 2023

# PACAS + Ozone – PAC-O<sub>3</sub>



- Combination integrated + post-treatment technology
- Less PAC
- Less Ozone
- High removal efficiency
  
- Feasibility study (STOWA 2020-23)
  
- Pilot study
  - June 2022 – October 2022
  - WWTP Leiden-Noord, Hoogheemraadschap Rijnland

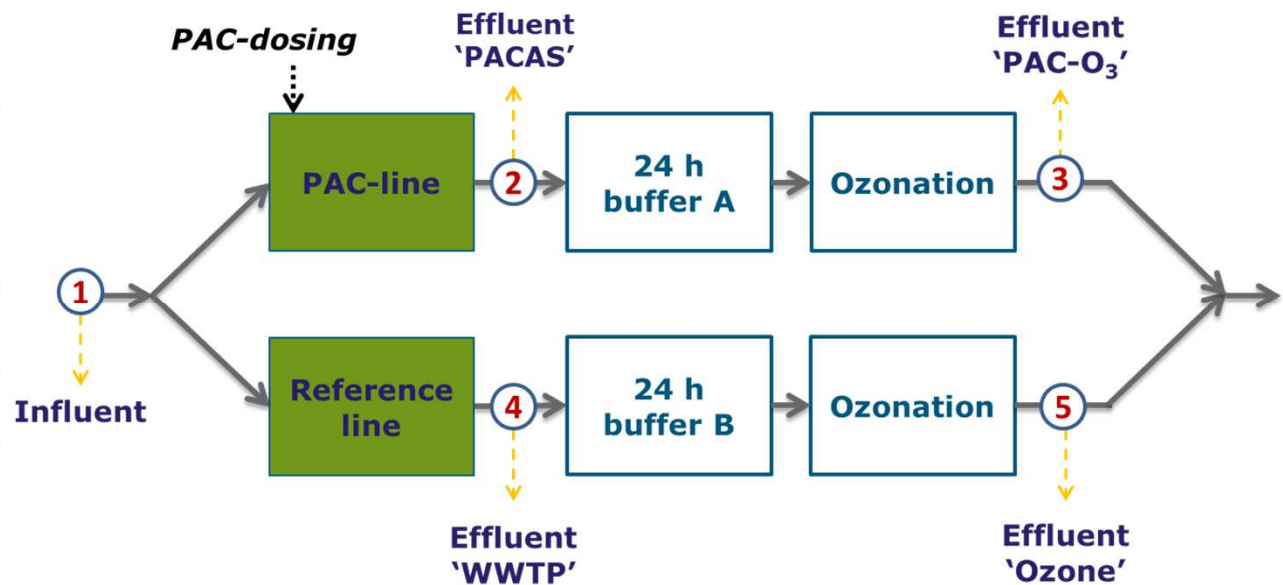
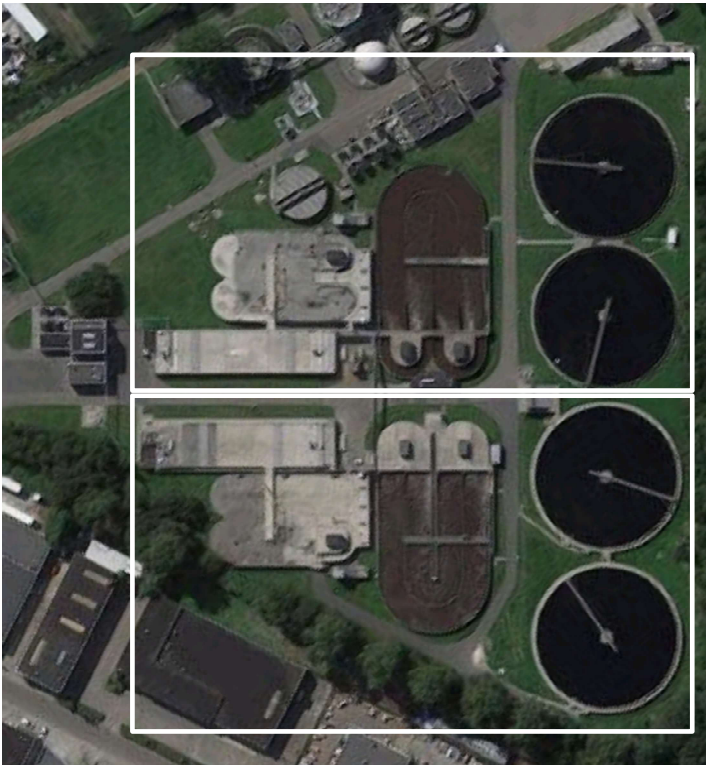
2 PAC-O3 pilot | 9 November 2023

## Consortium “PAC-O<sub>3</sub>”



# Research set-up

WWTP Leiden-Noord ca. 170,000 p.e.



Removal efficiency in relation to WWTP influent

# PACAS Leiden-Noord

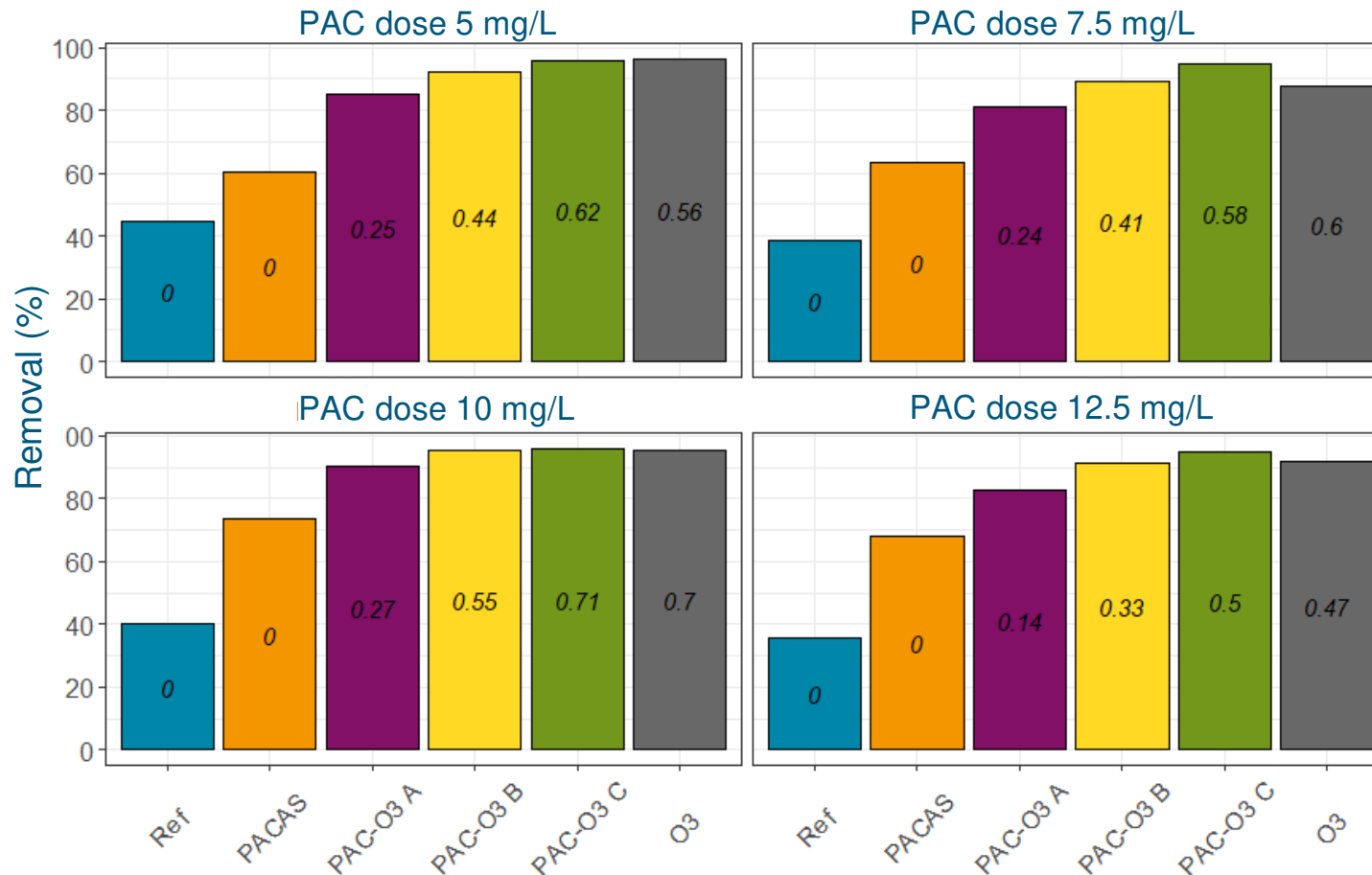


*Thank you to Hoogheemraadschap Rijnland for the hospitality!*

# Ozonation tests

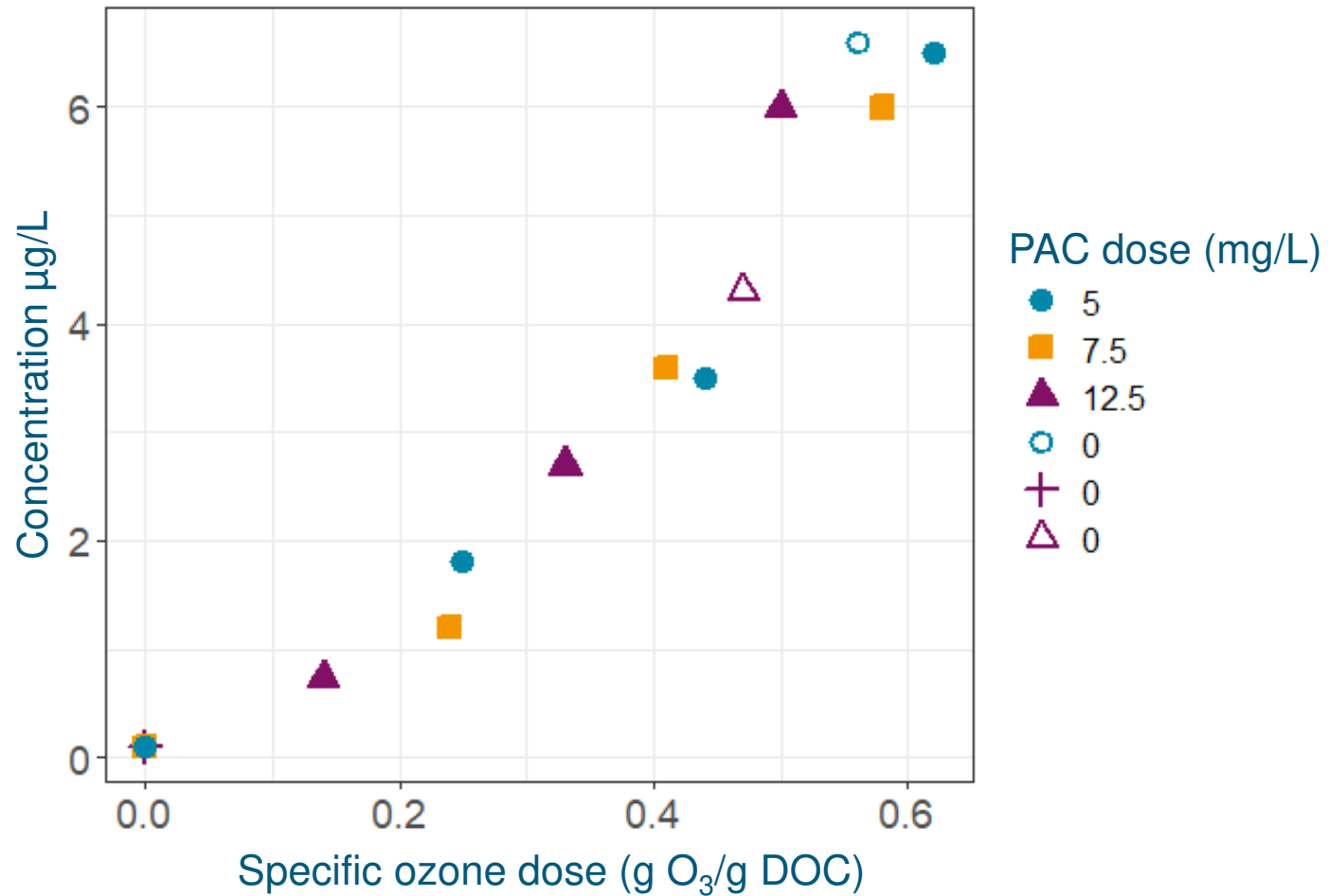


# Results PAC-O<sub>3</sub> - 7 best out of 11 guide substances



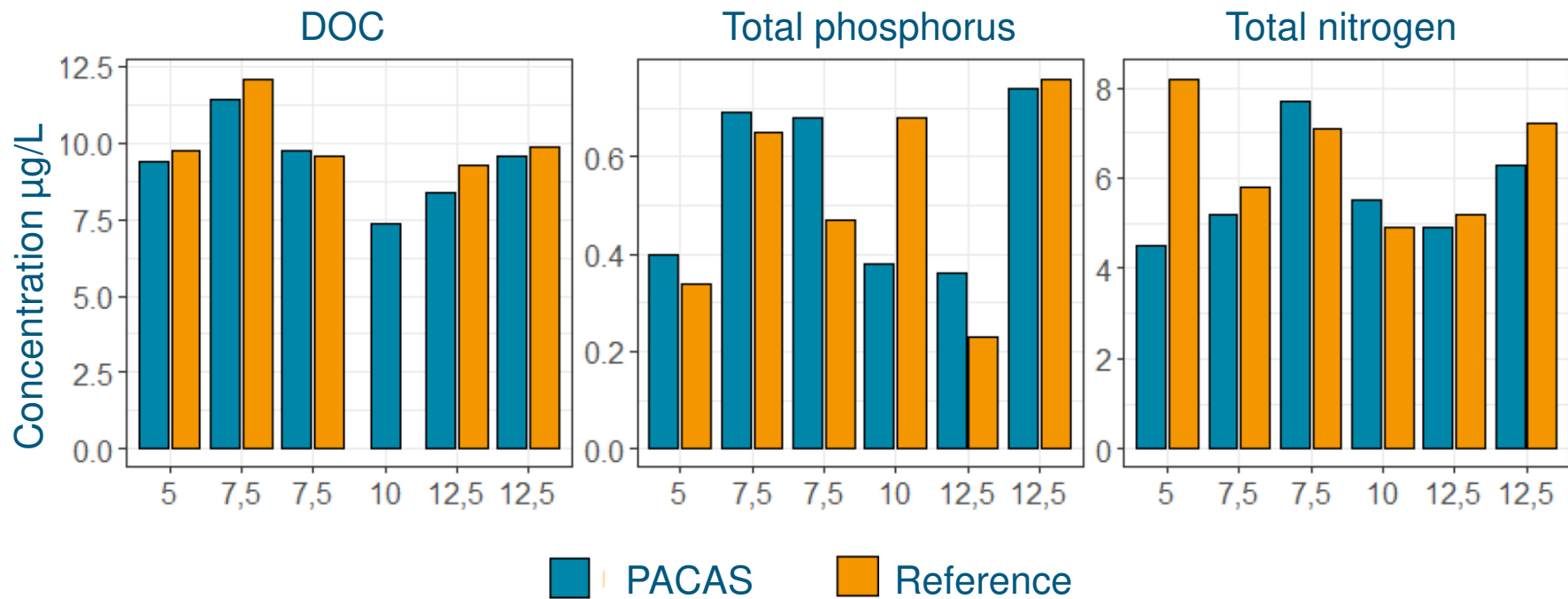
*Removal WWTP + post-treatment (in relation to WWTP influent) at dry weather flow. Post-treatment by-pass not included.*

# Bromate



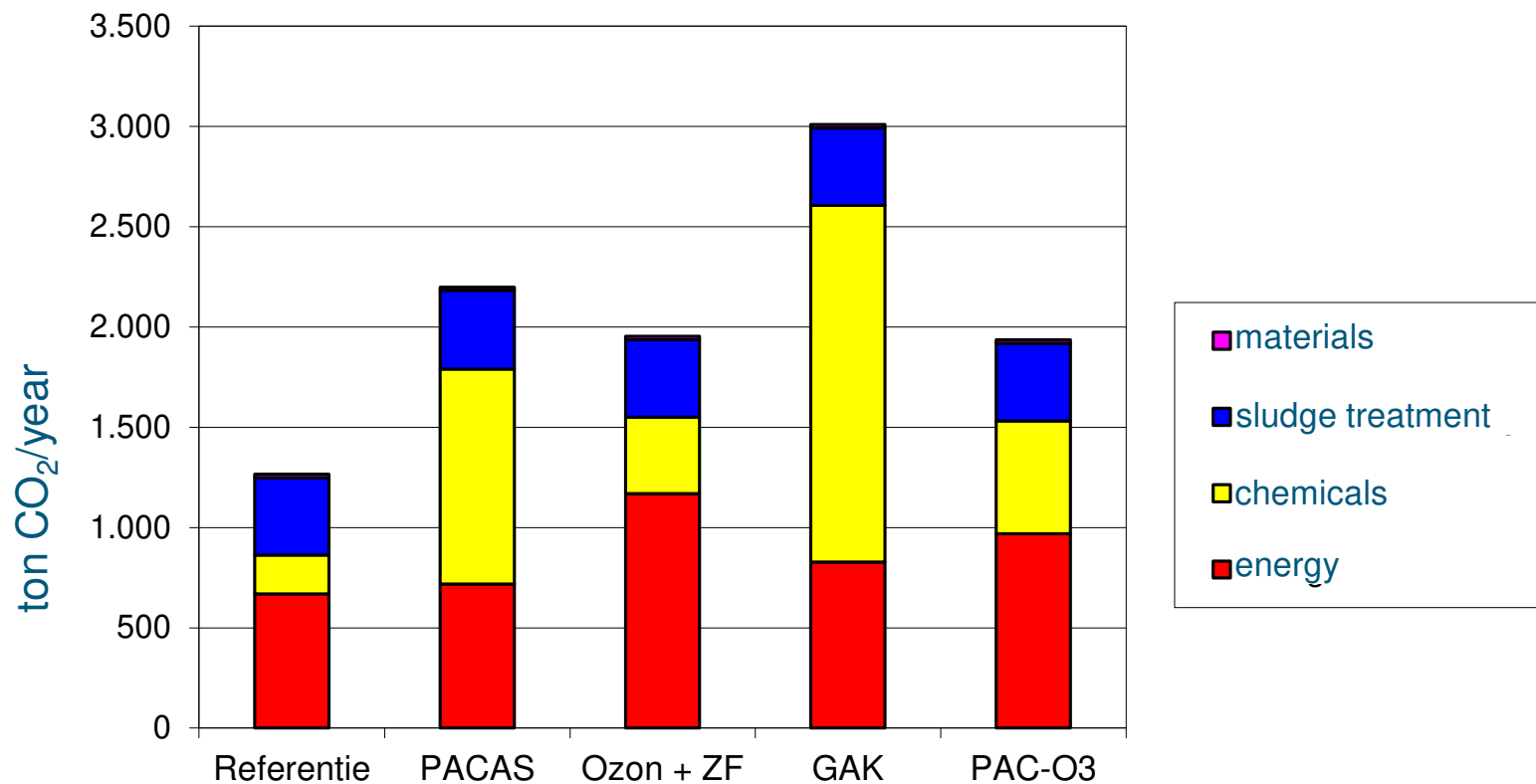
# Effect PACAS on DOC, P & N

- No improvement DOC, P and N removal





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



*PAC-dose 5 mg/L, specific ozonedose 0,3 g O<sub>3</sub>/g DOC.*

*Reference = WWTP without additional step for micropollutants removal*

# Summary performances

	UNIT	PACAS	Ozone + Sand Filtration	PAC-O <sub>3</sub> <sup>1</sup>
CO <sub>2</sub> -footprint <sup>2</sup>	g CO <sub>2</sub> /m <sup>3</sup>	122	128	106
Costs <sup>2</sup>	€/m <sup>3</sup>	0,05	0,17	0,10
Removal efficiency Dutch guide substances <sup>3</sup>	%	70-75%	80-85%	70-75%

<sup>1</sup> PAC dose 5 mg/L, specific ozone dose 0.3 g O<sub>3</sub>/g DOC.

<sup>2</sup> Per treated m<sup>3</sup> wastewater: peak dry weather flow must be treated. **Please note: standardized cost and CO<sub>2</sub> levels for 2018;** recalibration of all CO<sub>2</sub>- and cost levels will take place during the evaluation of the Innovation Program in 2024

<sup>3</sup> Overall removal efficiency of effluent wwtp to influent wwtp (including bypass post treatment) for 7 of 11 guide substances: benzotriazole, carbamazepine, diclofenac, irbesartan, gabapentine, metropolol, hydrochloorthiazide, mixture of 4- en 5-methylbenzotriazole, sotalol, trimethoprim and 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.

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

- PACAS will have a footprint of 160 g CO<sub>2</sub>/m<sup>3</sup> and a cost level of € 0.08/m<sup>3</sup>; no changes for ozone
- PAC-O<sub>3</sub> will have a footprint of 146 g CO<sub>2</sub>/m<sup>3</sup> and a cost level of € 0.12/m<sup>3</sup>

# Conclusies

- Effective and robust technology (TRL 9)
- Broader palet micropollutants than PACAS
- Less chances of producing bromate than stand-alone ozon
- Reduced ecotoxicity >50%
  
- Implementation
  - Sustainability still attention point (fossil origin PAC)
  - Fluctuations PAC prices (€ 2,000 in 2017 → € 4,000 - 6,000 in 2023)
  - 2 – 5% increase sludge production (ton ds/year)
  
- Urban Wastewater Treatment Directive
  - 80% removal EU-guide substances (effluent vs. influent)
    - Increase PAC dose to 7.5 mg/L
    - Increase specific ozone dose to 0.5 g O<sub>3</sub>/g DOC



**Thank you for your attention!**

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**stowa**

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

**November 8 and 9 2023**  
**Aquatech Amsterdam**



*Ministry of Infrastructure  
and Water Management* 2023

**Royal HaskoningDHV**