

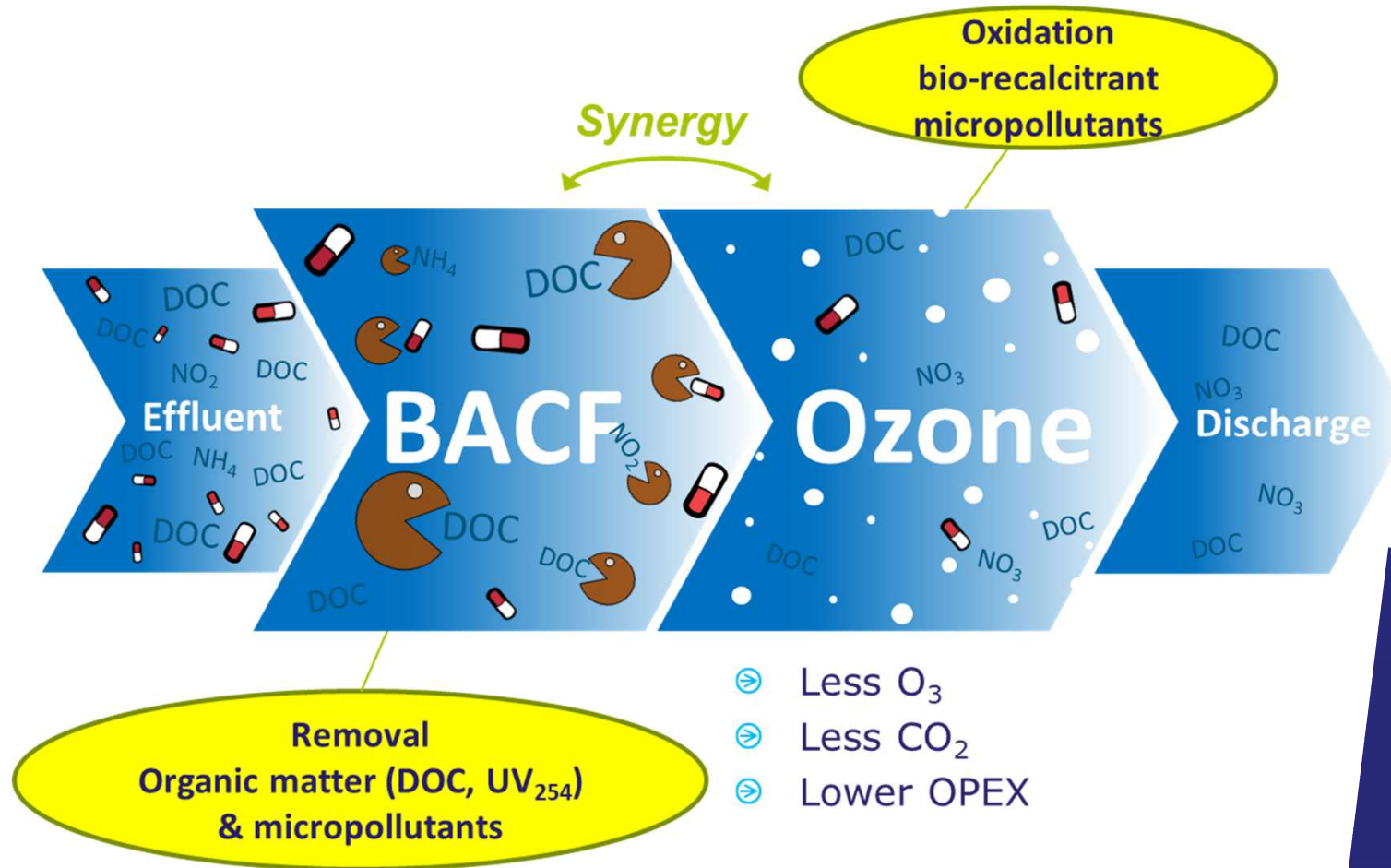
BO₃-technology

***Sustainable removal
of organic
micropollutants***

The BO₃-technology

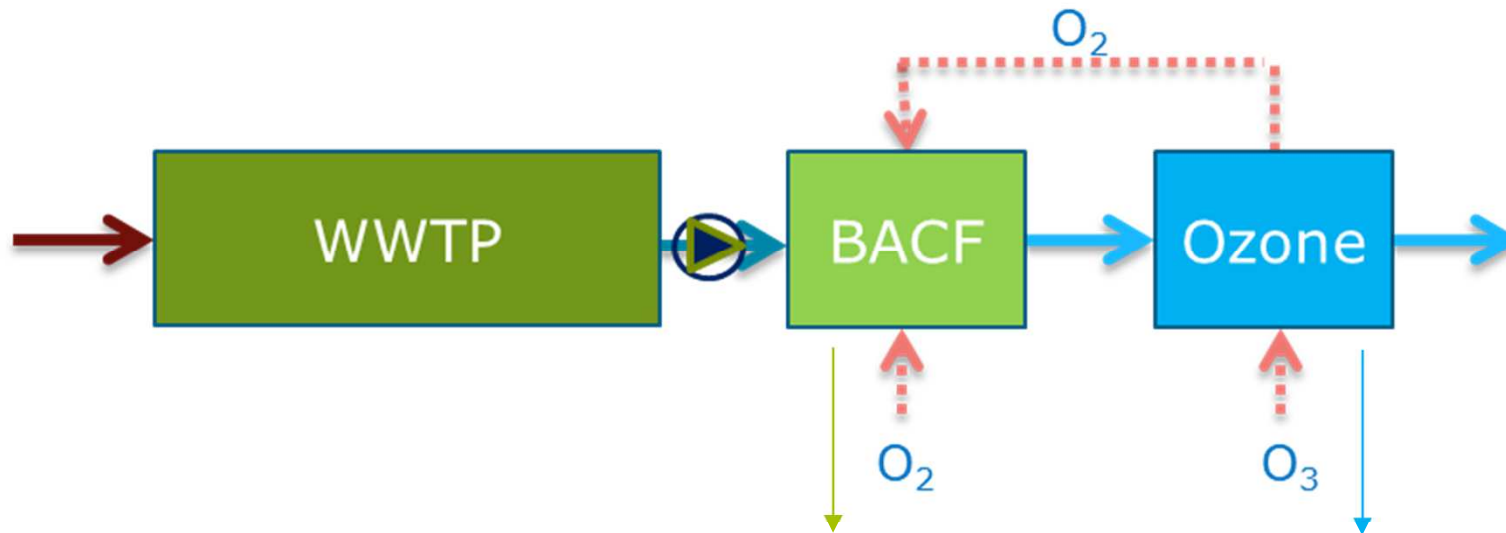
Development partners

WAGENINGEN
UNIVERSITY & RESEARCH



Pilot tests BO₃ at WWTP Horstermeer

- BACF operated with fully saturated granular activated carbon (>12 year)
- Flow ~2 m³/hour
- 7 months continuous operation (Oct '22 – Apr '23)



Studied parameters: Empty Bed Contact Time 22 - 30 - 60 minutes & Specific ozone dose 0.1 – 0.2 – 0.4 g O₃/g DOC

Pilot partners

waterschap
amstel gooi en vecht

stowa

Rijkswaterstaat
Ministry of Infrastructure
and Water Management

Royal
HaskoningDHV
Enhancing Society Together

Biological Activated Carbon Filtration



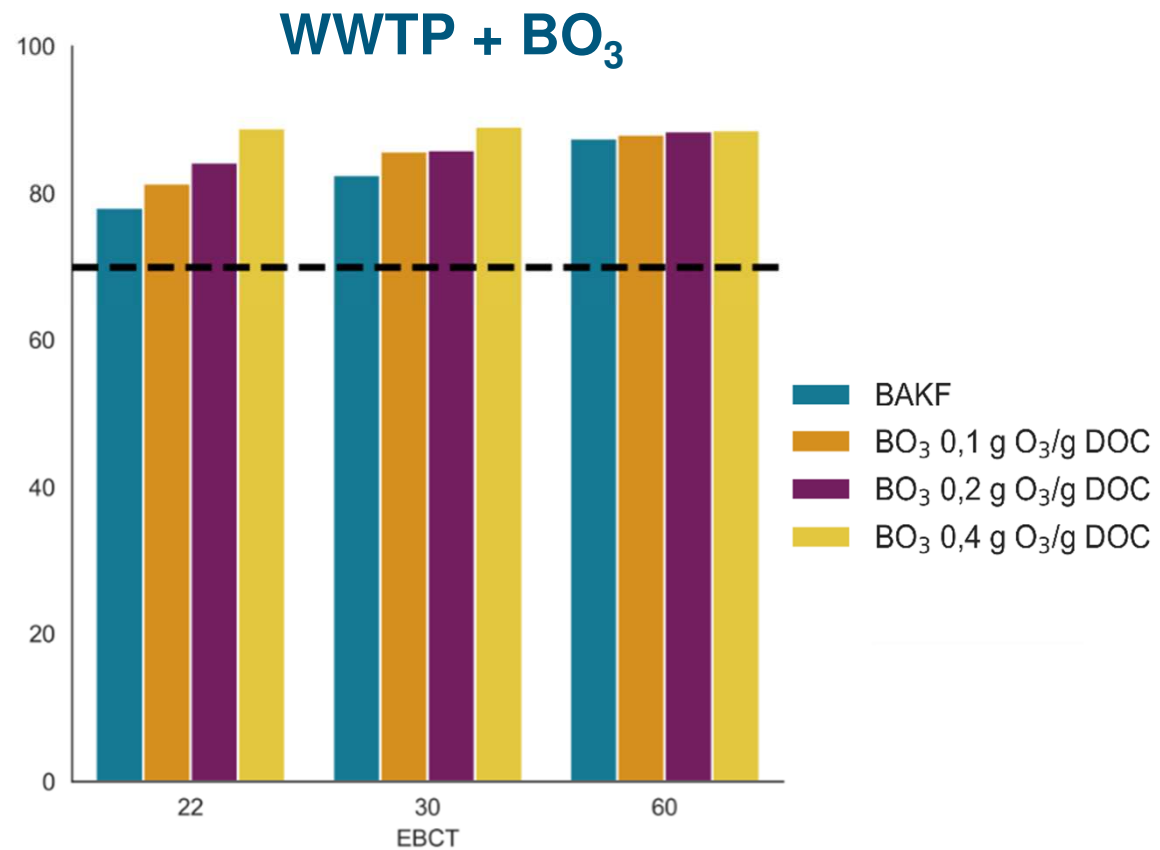
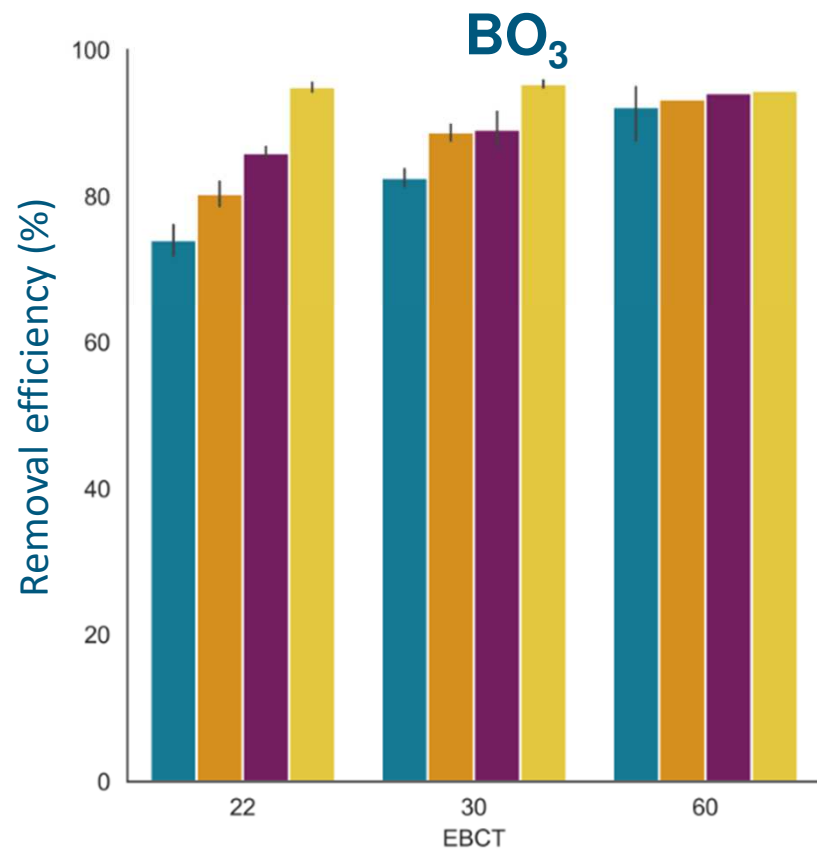
Granular Activated Carbon from BODAC NieuWater UPW Emmen



Ozone treatment

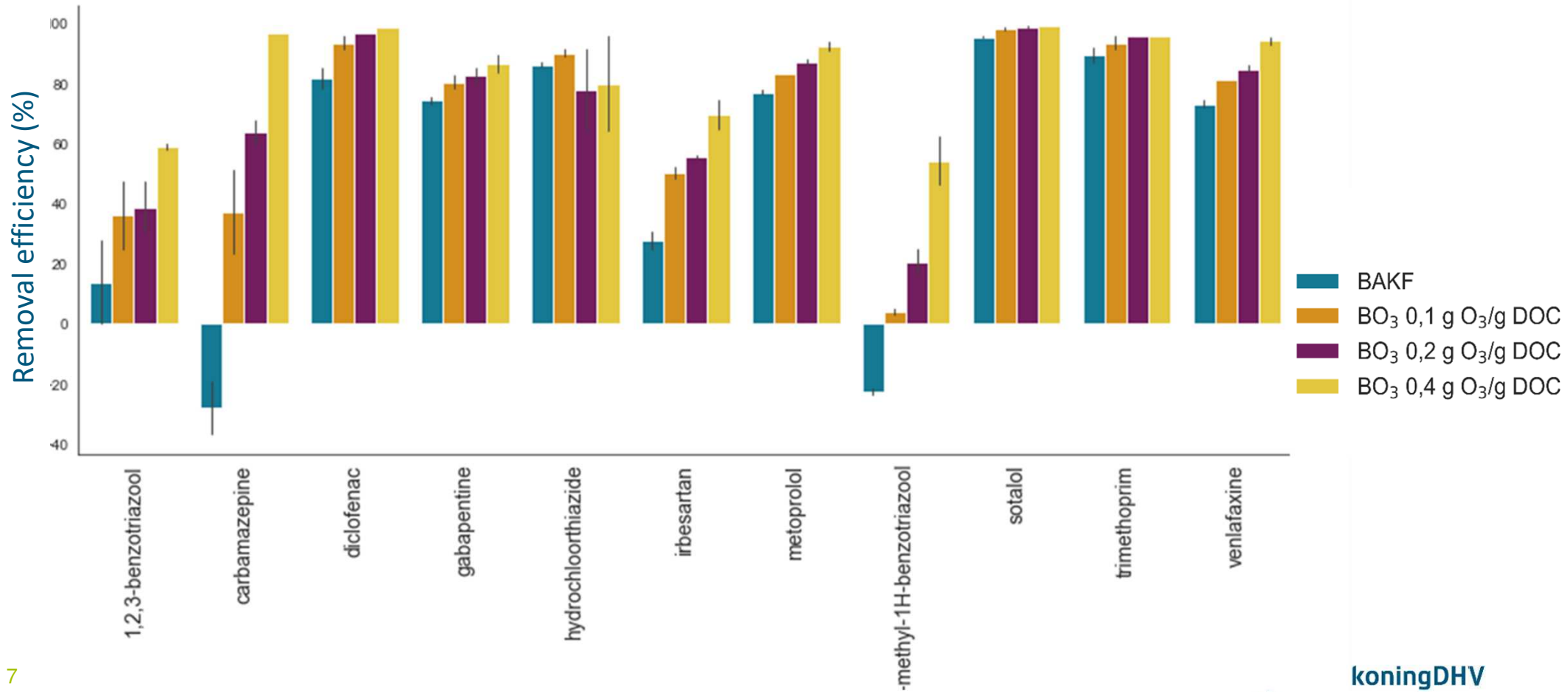


Removal 7 best of 11 guide substances

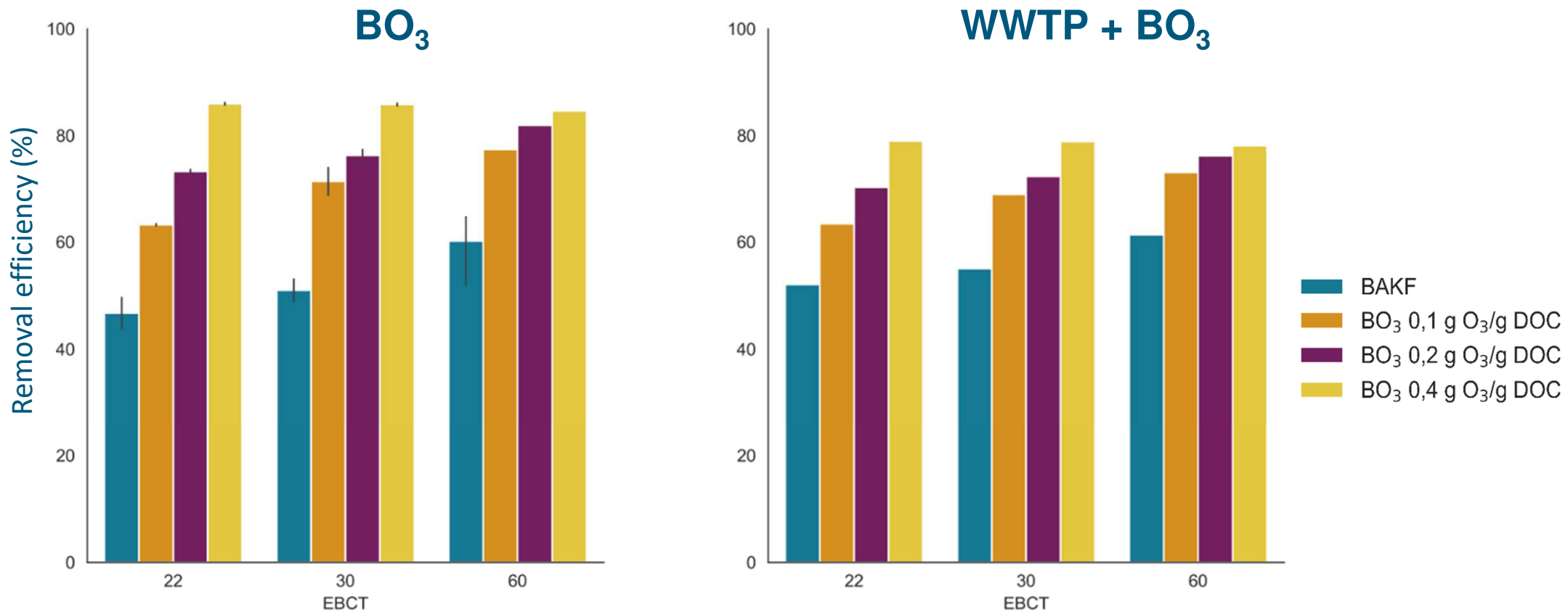


Removal 11 individual guide substances

BO₃ (excl. WWTP)

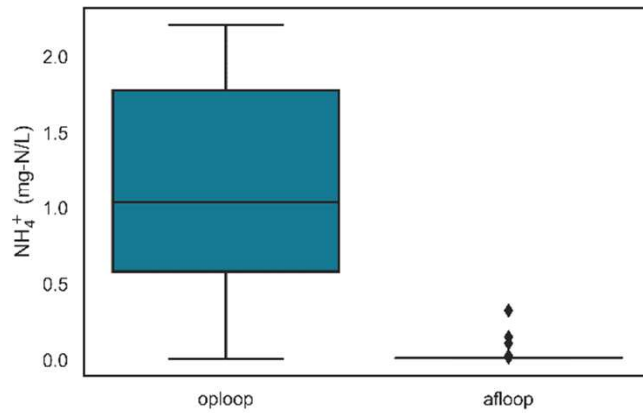


Removal 19 guide substances



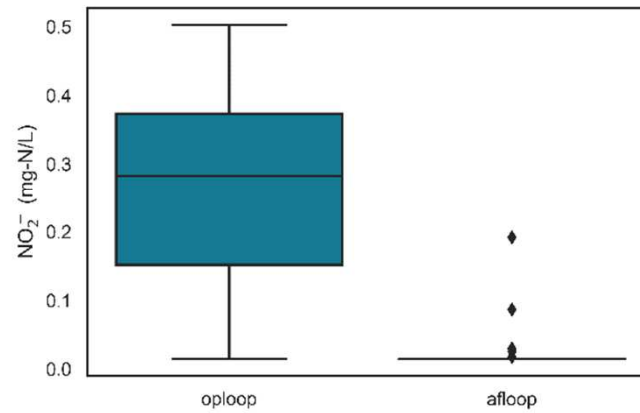
Nitrogen & Phosphorus

NH_4^+



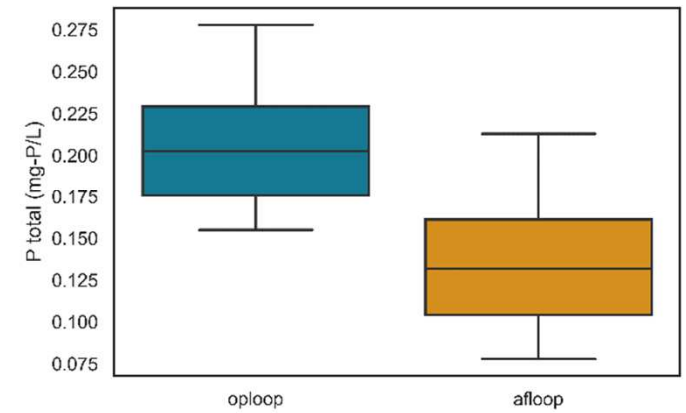
1.0 → <0.015 mg N/L

NO_2^-



0.3 → <0.015 mg N/L

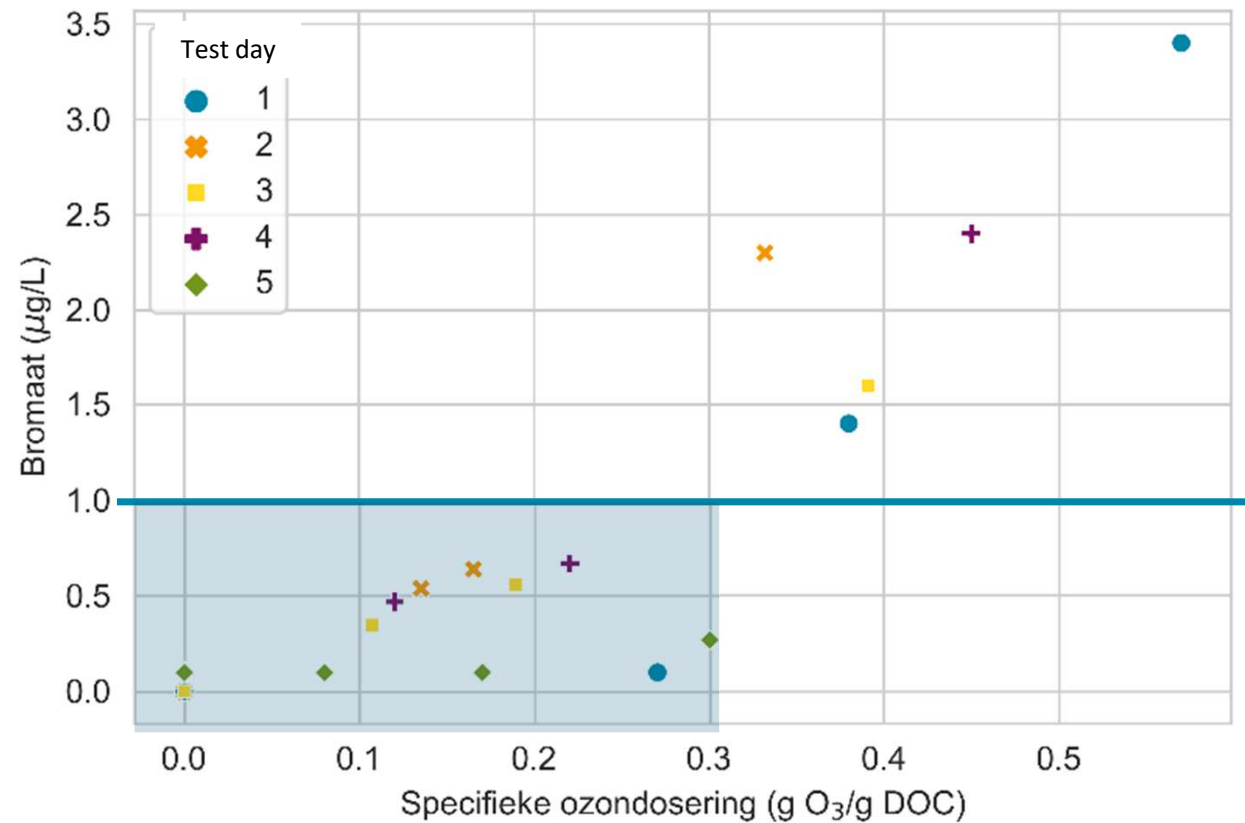
P-total



0.20 → 0.13 mg P/L

Bromide & Bromate

Test day	BACF in	BACF out
	Bromide (mg/L)	
1	0.34	0.26
2	0.68	0.59
3	0.38	0.37
4	0.39	0.40
5	0.17	0.17



Comparison with reference technologies

	UNIT	PACAS	Ozone + Sand Filtration	BO ₃ ¹
CO ₂ -footprint ²	g CO ₂ /m ³	122	128	70 - 81
Costs ²	€/m ³	0.05	0.17	0.13 – 0.15
Removal Efficiency Dutch guide substances ³	%	70-75%	80-85%	84 - 87%

¹ Two BO₃ configurations: 1) EBCT 22 minutes and 0.2 g O₃/g DOC and 2) EBCT 30 minutes and 0.3 g O₃/g DOC

² 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

³ 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, hydrochlorothiazide, mixture of 4- en 5-methylbenzotriazole, 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.

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 CO₂-footprint of 160 g CO₂/m³ and a cost level of € 0.08/m³
- No changes for ozone CO₂-footprint of 128 g CO₂/m³ and a cost level of € 0.17/m³
- No changes for BO₃ CO₂-footprint of 81 g CO₂/m³ and a cost level of € 0.15/m³

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Take home message

- High removal efficiency for organic micropollutants
 - Broad spectrum of compounds removed
- Minimal energy requirement
 - Electricity consumption 0.05 – 0.07 kWh/m³
- Sustainable technology
 - Carbon footprint 50 – 65 g CO₂/m³
- Low operational expenditures
 - OPEX savings 30 – 40% compared to ozone treatment
- Limited bromate formation
 - Below Dutch legal limit for surface water



Enhancing Society Together

Thank you for your attention!



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

stowa



**Ministry of Infrastructure
and Water Management**

**November 8 and 9 2023
Aquatech Amsterdam**

Royal HaskoningDHV