Welcome @ Sessions 6-9 Day 2

Overview Technologies Dutch Innovation Program

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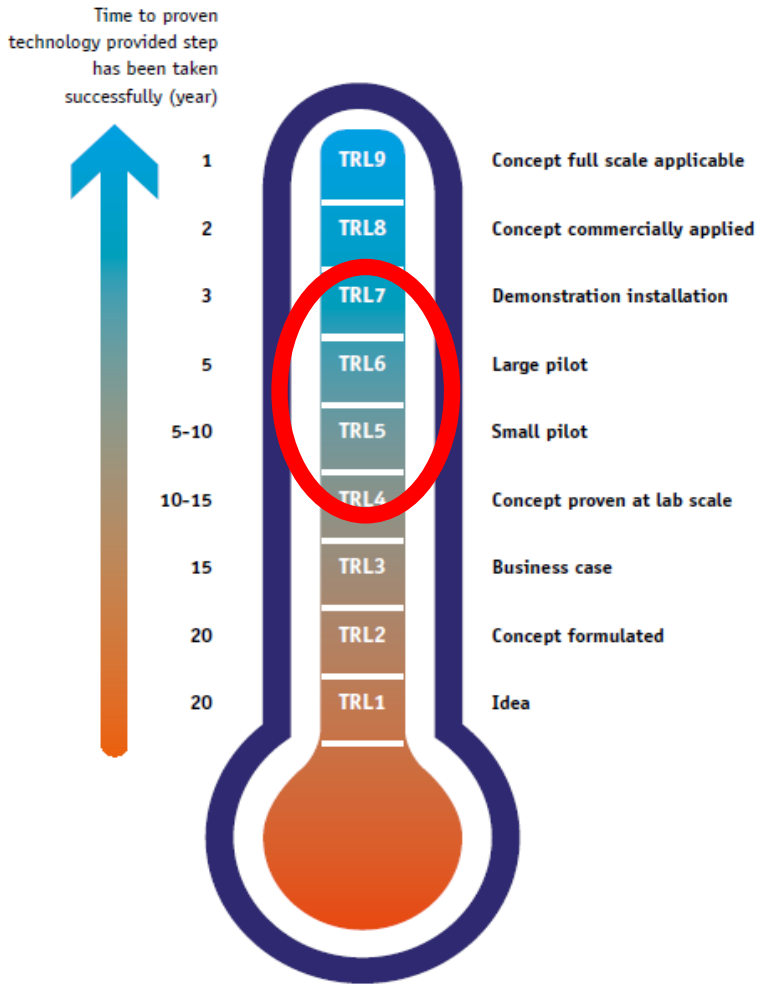
Ministry of Infrastructure and Water Management

Tackling Micropollutants in Muncipal Wastewater
Results of the Dutch Innovation and Implementation Program
November 8 and 9 2023
Aquatech Amsterdam

stowa

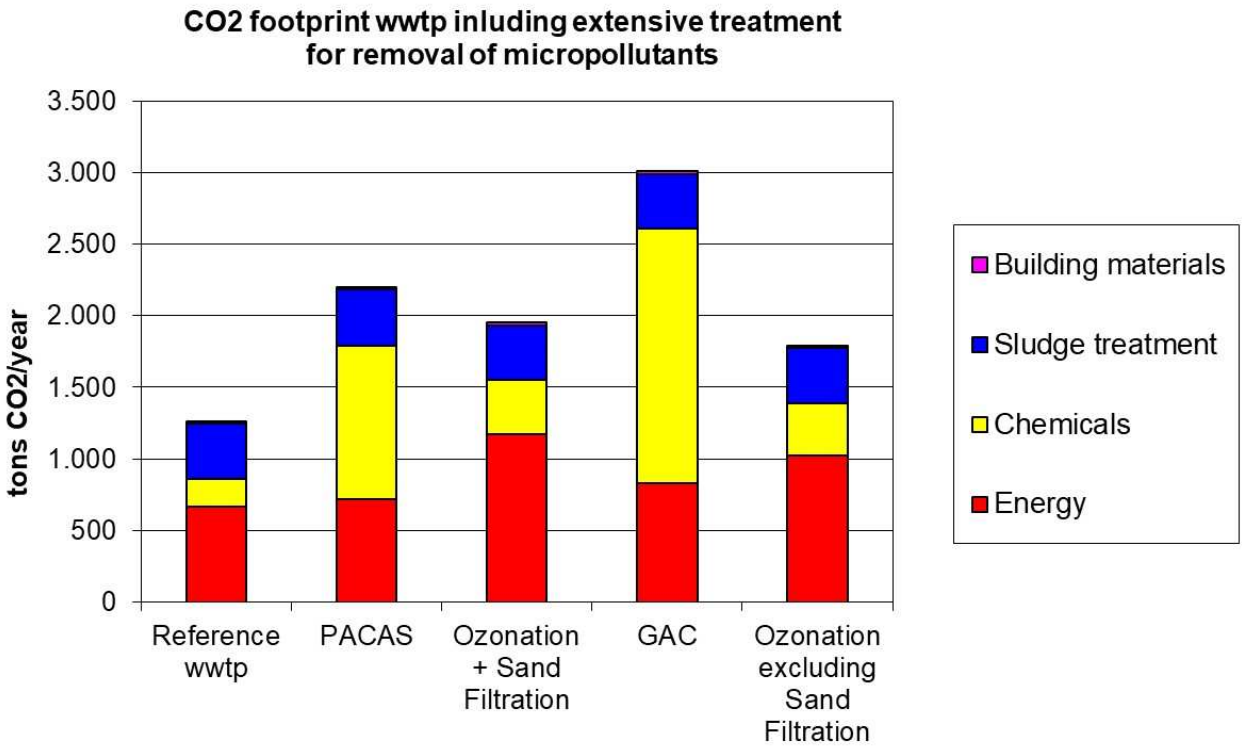
Goals NL innovation program

- Significant advantages on proven technologies:
  - Ozonisation + biological sand filtration (O3+biol. SF)
  - Powdered Activated Carbon in Activated Sludge (PACAS)
  - Granular Activated Carbon Filtration (GAC)
- For removal efficiency, CO2 footprint, effluent quality and/or costs
- Are on the verge of breakthrough:
  through R&D in this program implementation is possible on demo scale in **2025-2027**



Standard CO2 and cost calculations

- Standard: 100.000 p.e. wwtp with digestion
- Standardized costs and CO2 values per kWh, natural gas, but also for chemicals and sludge treatment
- CO2 Excel Model: comparison of researched technology with reference technologies



Criteria Innovation Program

	Costs (euro/m³) [13]	CO2-footprint (g CO2/m³) [1]	Removal efficiency [2]
PACAS	0,05	122	70-75%
Ozone + biological sandfiltration	0,17	128	80-85%
GAC	0,26	325	80-85%

Guide Substances NL	Categorie 1 EU	Categorie 2 EU
carbamazepine	amisulpride	benzotriazol
diclofenac	carbamazepine	candesartan
hydrochloorthiazide	citalopram	irbesartan
metoprolol	clarithromycine	som 4- en 5-methyl-1H-benzotriazol
venlafaxine	diclofenac	
1,2,3-benzotriazool	hydrochloorthiazide	
irbesartan	metoprolol	
som 4- en 5-methyl-1H-benzotriazol	venlafaxine	
gabapentine		
sotalol		
thrimethoprim		

[1] Per treated m³ wastewater: peak dry weather flow must be treated
[2] Minimum removal efficiency influent wwtp – effluent wwtp

70% in every 24h or 48h sample for Dutch guide substances
[3] Cost Levels 2018

EU: Minimum removal efficiency influent wwtp – effluent wwtp

80% in every 24h or 48h sample for EU guide substances; ratio 2:1 for EU category 1 vs 2

Difficult for NL conditions: Amisulpride, Clarithromycine and Candersartan are in too low levels present in influent and effluent of Dutch wwtp's

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DUTCH INNOVATION PROGRAM

O3-STEP (Horstermeer)

Upflow µGAC + lucht (Hapert)

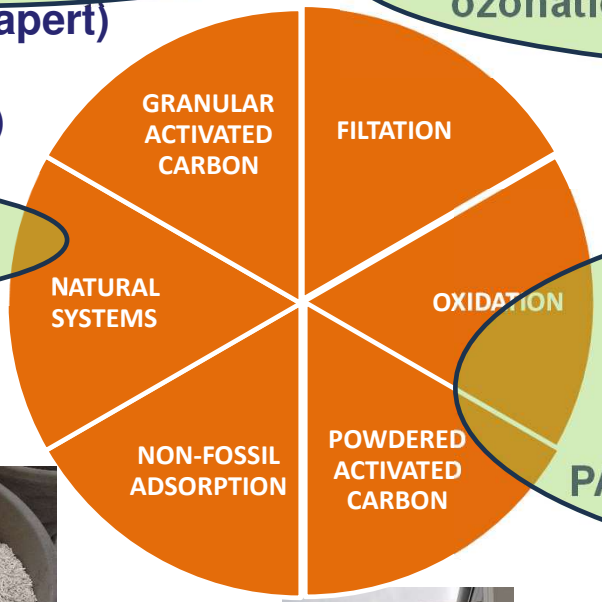
Bio-GAC (air) (Emmen)

BODAC - O2 (Emmen)

nano filtration + UV oxidation (Asten)

ozonation and ceramic filtration (Wervershoof)

Quickscan natural systems



Literature study + guidelines using ozone in NL

Microforce (O3 biofilm reactor; Walcheren)

B-O3 (bio pretreatment + ozone Horstermeer

PAC-O3 (Leiden Noord)

Fossil free carbon

AdOx, zeolites (Leiden)

Dexsorb, cyclodextrines (Lelystad)

PACAS Nereda (Simpelveld)

PAC+cloth filtratiion(Vinkel)

PAC in effluents

Micros in digestion and

Influences of PAC dosage

Technologies Today (day 2)

Oxidation

- O3-STEP: Combined ozonation and discontinuous GAC-filtration @ Horstermeer
- PAC-O3: PACAS + post ozonation treatment @ Leiden Noord
- Microforce: Combined ozonation and biofiltration @ Walcheren
- B-O3: Biological pretreatment + ozonation @ Horstermeer

Other technologies

- Ozonation and ceramic filtration @ Wervershoof
- Nanofiltration and UV-treatment @ Asten
- Quick Scan Natural systems

Do’s and dont’s

- Limiting formation of byproducts and bromate
- Sampling and analysis

Effects of enhanced removal of micropollutants on PFAS and Antibiotic Resistance

First Evaluation Performances: CO2

CO2 footprint (g CO2/m³) [1]	70-80% overall removal efficiency Dutch substances[2]	≥ 80% overall removal efficiency Dutch subtances[2]	≥80% overall removal efficiency EU substances[2]
≤ 80	**Ozonation 0,5 g O3/gDOC** B-O3 Microforce *Natural Systems*	B-O3 Microforce	B-O3 Microforce
80-120	PAC/O3	**Ozonation 0,6 g O3/gDOC** PAC/O3	**Ozonation 0,7 g O3/gDOC**
120-160		**Ozonation 0,7 g O3/gDOC + sand filtration**	PAC/O3
160-200	O3-STEP	Ozonation + Ceramic Filtration *O3-STEP*	*O3-STEP*
≥ 250	Ozonation + Ceramic Filtration Nanofiltration + UV-treatment	Ozonation + Ceramic Filtration Nanofiltration + UV-treatment	Ozonation + Ceramic Filtration Nanofiltration + UV-treatment

[1] Per treated m³ wastewater: peak dry weather flow must be treated

[2] Minimum removal efficiency influent wwtp – effluent wwtp (extensively treated effluent + bypass) in every 24h or 48h sample

Italic: pilot studies have not proven the removal efficiencies and/or CO2-footprint: results are extrapolated

First Evaluation Performances: Costs

Costs are based on price level 2018 => costs are not absolute but relative so that technologies can be compared!

Goal: removal of more than 80% of guide substances NL

- ≤ € 0,15 per treated m3: Ozonation ≤ 0,7 g O3/g DOC, Microforce, B-O3, PAC-O3
- ≥ € 0,15 per treated m3: O3-STEP, natural systems
- ≥ € 0,40 per treated m3: nano+UV, ozonation + ceramic filtration

Please mind: cost levels will go up by 50-100% based on price levels in 2024 compared to 2018, exact calculations will be given in the evaluation report of the Innovation Program mid 2024

Knowlegde Gaps Oxidation

Optimizations

- Energy use
- Lowering bromate formation
- Enhancing removal of micropollutants
- Use of liquid oxygen of oxygen from air

Dispersion systems: which dispersion systems are best for

- Ozone uptake
- Reducing bromate formation
- Energy Consumption
- Removal of Micropollutants

Knowledge Gaps Oxidation (2)

Combinations of Adorption and ozone

- If GAC is used in combination with ozone as a pretreatment or as a post treatment: How long can one filling last?
- How can you regenerate the adsorption material? What is the percentage of loss during regeneration?
- Which pretreatment is necessary (filters, screening)
- Can you optimise the composition of the adsorption materials?
- If PAC is used: how much of the used PAC ends up in effleunt
- Can you use non-fossil PAC?

General Remarks

What is your goal?

- Effluent quality (nutrients, micros, ABR, PFAS)
- Targeting a multispectrum of micropollutants => combinations of technologies?!
- Reuse of water?
- At which cost?
- At which CO2 footprint?

=> specific locations and context call for specific measures!

General

- How do you measure the removal efficiency of a wwtp including posttreatment? Correct sampling is challenging due to the hydraulic retention time of a wwtp and rain weather

Further information

GO TO WWW. STOWA.NL/IPMV

- 15 pilot studies: results expected to be published by end 2023
- 21 feasibility studies PAC, GAC, Ozone, Other Adsoprtion Materials, but also technologies which were not piloted
- 3 reports on influence of PAC-dosage: on digestion and return of dirty water, sludge incineration and effluent quality (PAC measurement in effluent)
- Literature study byproducts ozonation and guidelines on how to prevent them
- Quick scan possibillities natural systems
- webinars results pilot studies (spoken in Dutch but with English subtitles!) september 2023 – march 2024
- Evaluation Innovation Program - Summary results incl costs level: expected mid 2024
- Reports on sampling and analysis procedures and techniques
- And more…..

Thank you for your attention!

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