Welcome @ Afternoon Sessions Day 1

Overview Technologies Dutch Innovation Program

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Tackling Micropollutants in Municipal Wastewater

Results of the Dutch Innovation and Implementation Program

November 8 and 9 2023

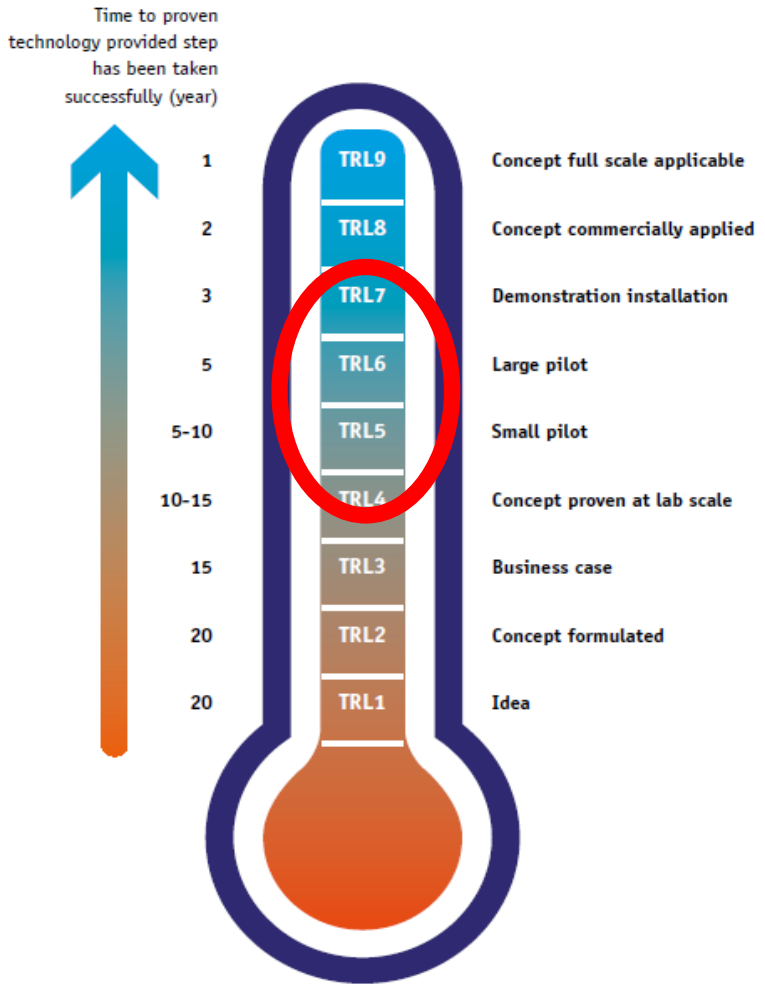
Aquatech Amsterdam

Ministry of Infrastructure and Water Management

stowa

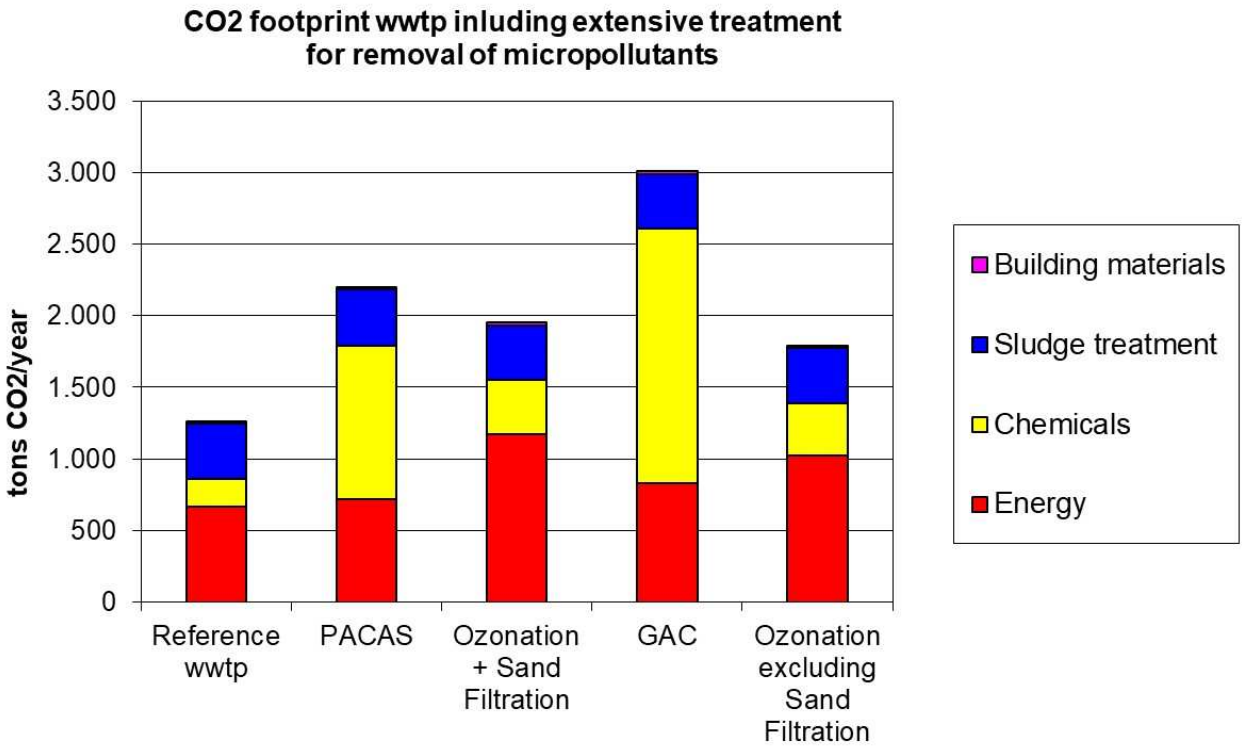
Goals NL innovation program

- 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)

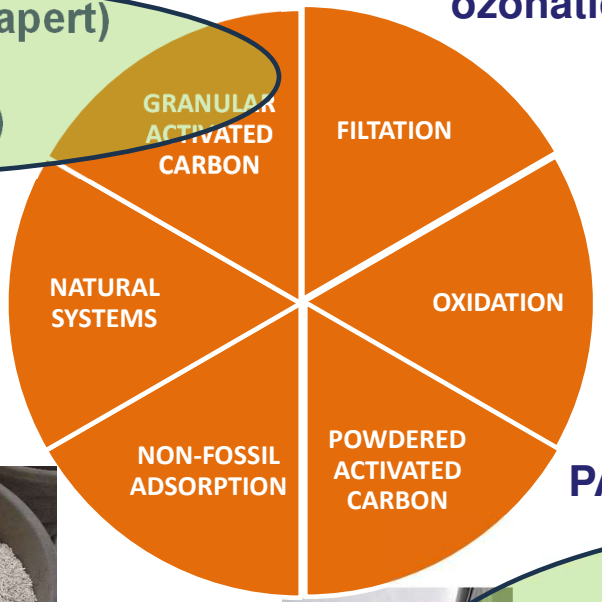
Upflow µGAC + lucht (Hapert)

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 1): Adsorption

GAC filtration

- Continuous Upflow GAC: CarboPlus and DynaCarb pilots @ Hapert
- Combined adsorption and biological degredation:
  Continuous Bio_GAK_air and discontinuous BODAC_O2 @ Emmen

PAC

- PACAS in aerobe granuled activated sludge systems (Nereda) @ Simpelveld
- Post PAC and Cloth treatment @ Vinkel
- Measuring PAC levels in wwtp effluent
- Fate of micro's in digestion and influence of PAC-dosage in Activated Sludge (PACAS)

Non-fossil adsorption

- Non-fossil PAC
- Zeolites (AdOx) including in situ regeneration with ozone @ Leiden Noord
- Cyclodextrines (DEXSORB) @Lelystad

First Evaluation Performances Adsorption: 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	PACAS Non Fossil AC		
80-120	PAC/CLOTH BODAC-O2 BIO-GAC-AIR	PACAS Non Fossil AC *BIO-GAC-AIR*	PACAS Non Fossil AC *BIO-GAC-AIR*
120-160	**PACAS Fossil AC** CARBOPLUS AdOx DYNACARBON	PAC/CLOTH *BODAC-O2*	*BODAC-O2*
160-200	*DEXSORB*	**PACAS Fossil AC** *CARBOPLUS* *AdOx* *DYNACARBON*	*PAC/CLOTH* **PACAS Fossil AC** *CARBOPLUS* *AdOx* *DYNACARBON*

[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 Adsorption: Costs

Costs are based on price levels 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: PACAS AC, PACAS Non-Fossil, Ozonation ≤ 0,7 g O3/g DOC, PAC/Cloth
- ≥ € 0,15 per treated m3: BODAC-O2, Bio-GAC-AIR, CARBOPLUS, DYNACARBON, AdOx, DEXSORB

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 Adsorption

GAC filtration

- How long can one filling of GAC last?
- Which circumstances are needed for biological degradation in GAC filters (O2, EBCT, load)
- How to manage the dip in removal efficiency of GAC filters loaded with fresh carbon where bioligical degradation has not sufficiently started yet and the GAC breaks through due to limited adsorption spaces.
- What is the regeneration capacity of biologically loaded GAC? Can biologically loaded GAC which have lasted for more than one year be regenerated? What is the percentage of loss during regeneration?
- Which pretreatment is necessary (filters, screening)
- Which type of GAC is needed? Is it possible to make non-fossil GAC?

Knowlegde Gaps Adsorption (2)

Non-fossil adsorption

- 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?

PAC

- How much of the used PAC ends up in effleunt
- Do non-fossil PACS really perform just as well as fossil PACS ?(only one type tested)

General Remarks

What is your goal?

- Effluent quality (nutrients, micros, ABR, PFAS)
- 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 will be published (reports on water factories, hydraulic design, ABR, PFAS)

Thank you for your attention!

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