



Removal of Micropollutants from Wastewater

Cora Uijterlinde STOWA

Tackling Micropollutants in Wastewater

Results of the Dutch Innovation and Implementation Program

November 8 – 10, 2023

Aquatech Amsterdam



Rijkswaterstaat
*Ministry of Infrastructure
and Water Management*



Innovation program micropollutants

Hosted by STOWA

Funded by Ministry, STOWA and regional water authorities
(€ 11,7 mln; 2019-2023)

Focus on:

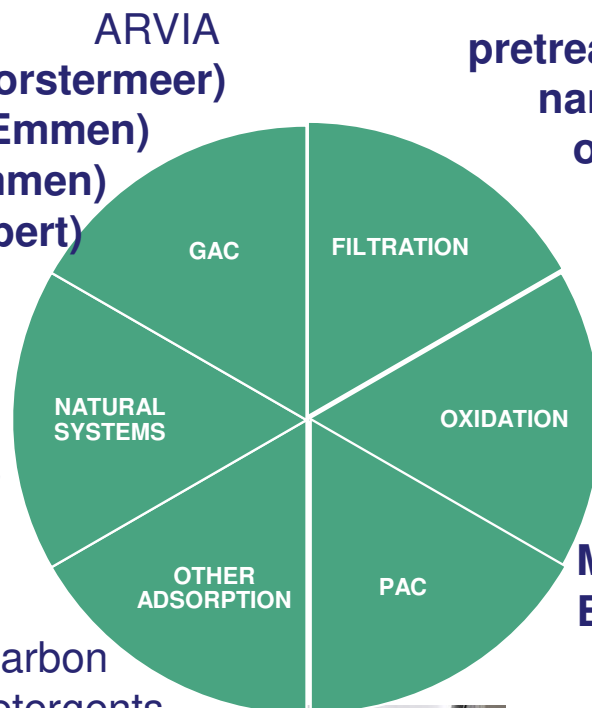
- ⇒ Treatment technologies on the threshold of breaking through → TRL 7 in 2025
- ⇒ Technologies should have an added value compared to existing techniques (removal rates, costs, sustainability or eco-toxicological risks)
- ⇒ Feasibility studies (100.000 pe) and **PILOT PLANT** research



	Unit	PACAS	Ozone+sand filter	GAC
CO ₂ footprint	g CO ₂ /m ³ ⁽¹⁾	116	119	325
Costs	€/m ³ ⁽¹⁾	0.05	0.17	0.26
Removal efficiency guide substances Ministry of Infrastructure and Water Management	% ⁽²⁾	70-75%	80-85%	80-85%



INNOVATION PROGRAM



ARVIA
 O3-STEP (Horstermeer)
 BODAC-O2 (Emmen)

Continuous Bio-GAC + air (Emmen)
 Continuous Upflow μ GAC (Hapert)

Quick scan
 natural systems

Fossil free carbon
 Zeolites in detergents

Fossil free adsorbents in sand filtration
AdOx, zeolites filtration (Leiden)
Dexsorb, cyclodextrines (Lelystad)

pretreatment – nano filtration (Waterfactory Wilp)
 nano filtration effluent (Asten)
 ozone with ceramic micro filtration (Wervershoof)
 Pharem - enzymes

Ultrasound and ozon (Winterswijk)
 PACO3 (Leiden-Noord)
 UV (Aarle Rixtel)
 Ozone (Aarle Rixtel)
Microforce O3 and biofilm reactor (Walcheren)
B-O3 biological pretreatment, ozone (Horstermeer)

PACAS + Fe
 PACAS Nereda (Simpelveld)
 PAC+cloth filtration (Vinkel)



- www.stowa.nl/IPMV
- Overall results in 2024





Ministerie van Infrastructuur en Waterstaat

HAALBAARHEIDSTUDIE HOLLE VEZEL NANOFILTRATIE VOOR VERWIJDERING VAN MICROVERONTREINIGINGEN OP RWZ'S



Ministerie van Infrastructuur en Waterstaat



PILOT PAK + DOEFILTRATIE



2022

45

RAPPORT



Ministerie van Infrastructuur en Waterstaat

VERKENNING NATUURLIJKE ZUIVERINGSSYSTEMEN VOOR VERWIJDERING VAN ORGANISCHE MICROVERONTREINIGINGEN



Ministerie van Infrastructuur en Waterstaat



Ministerie van Infrastructuur en Waterstaat

TOEGANG VAN HET PIJLREM FILTRATION IN ZUIVERINGSTECHNIEK ERWIJDERING VAN ONTREINIGINGEN OP ERZUIVERINGEN



Ministerie van Infrastructuur en Waterstaat



PILOTONDERZOEK VERGELIJKING OXIDATIEVE TECHNIEKEN EFFLUENT RWZI AARLE-RIXTEL



2020

41

RAPPORT



Ministerie van Infrastructuur en Waterstaat

TOEGANG VAN DE A NYX® TECHNOLOGIE KOSTENRIJK VOOR DE VERWIJDERING VAN REUKSTOFFEN OP ROEGWATERZUIVERINGEN



Ministerie van Infrastructuur en Waterstaat



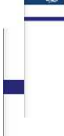
HEILIGERDORP VERKENNEND PILOTONDERZOEK



2023

30

RAPPORT



Ministerie van Infrastructuur en Waterstaat

HAALBAARHEIDSTUDIE POEDERKOOLODOSERING IN NEREDA® VOOR VERWIJDERING VAN MICROVERONTREINIGINGEN OP RWZI SIMPELVELD



Ministerie van Infrastructuur en Waterstaat



VERWIJDERING VAN MEDICIJNRESTEN MET BEHULP VAN OZON EN ULTRASOUND



HAALBAARHEIDSTUDIE DUURZAME ALTERNATIEVEN VOOR POEDER ACTIEFKOOL



Ministerie van Infrastructuur en Waterstaat



L O P

DU_3_IET

2023

10

RAPPORT

www.stowa.nl/ipmv

40 reports (Dutch)
 google translate, ChatGTP
 Translation on request (time)
 Webinars: subtitled

	feasibility study	pilot plant research	webinar
POWDER ACTIVATED CARBON (PAC)			
powder activated carbon with cloth filtration	2020-21	2022-45	27-sep-23
PACAS in combination with Fe-dosing	2021-37		
PACAS Nereda	2020-20	not available yet	27-sep-23
powderactivated carbon and sludge	2020-19		
GRANULAIR ACTIVATED CARBON (GAC)			
Biological Oxygen-Dosed Active Carbon (BODAC)	2020-46	not available yet	
O3-Step	2020-18	not available yet	11-okt-23
ARVIA	2020-17		
Continu Upflow µGAC + air	2021-36		
Continuous Bio-GAC + air	???	not available yet	
OXIDATION			
Ozone and UV		2022-41	
Ultrasound Usoniq	2020-24	not available yet	11-okt-23
PAC O3	2020-23	not available yet	11-okt-23
Oxidation products	literatuur 2022-47 handreiking 2022-48		
Microforce; O3 biofilm	2022-14	not available yet	
BO3; biological pretreatment with O3	2022-41	not available yet	
ALTERNATIVE ADSORPTION			
Zeolites	2022-32		
Cyclodextrines, Dexasorb, Dexfilter	2021-38	not available yet	
Sustainable alternatives activated carbon	2021-24		
Sandfiltration	2022-56		
AdOx, zeolites with filtration	2022-10	not available yet	
FILTRATION			
Pharem Filtration System	2021-59		
Nanofiltration	2020-22	not available yet	
Waterreuse; pretreatment - nanofiltration		not available yet	
Waterreuse: ozone with ceramic microfiltration	2020-25	not available yet	11-okt-23
NATURAL SYSTEMS			
Natural systems	2022-42		
MISCELLANEOUS			
Effects of PAC at sludge digestion			27-sep-23
Measuring PAC in effluent			27-sep-23

LEARNING COMMUNITY

Publications

Symposia

Network

Community of practice

Experts

Learning by doing

Webinars



- December 6: Adsorption, oxidation, filtration, biological removal
- January 31, 2024: oxidation, adsorption
- February 28: Bio-GAC and overall evaluation



IMPLEMENTATION AT FULL SCALE (2020-2023)

OZONE*

Wervershoof
(Hollands
Noorderkwartier)

Horstermeer
(Amstel Gooi en Vecht)

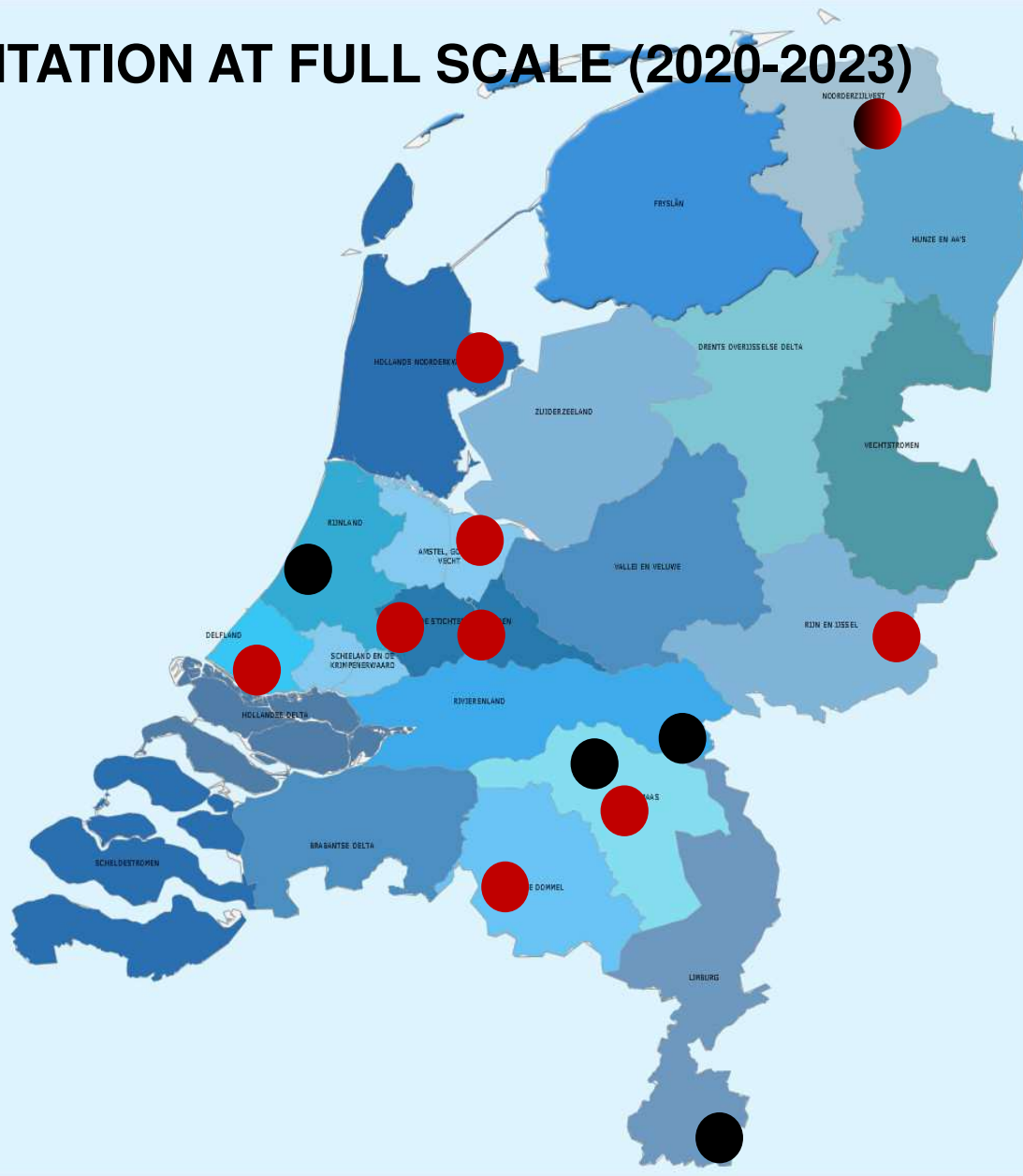
**Houten
Woerden**
(De Stichtse Rijnlanden)

De Groote Lucht
(Delfland)

Winterswijk
(Rijn en IJssel)

Dinther
(Aa en Maas)

Hapert
(De Dommel)



ACTIVATED CARBON

Leiden Noord
(Rijnland)

Groesbeek
(Rivierenland)

Oijen
(Aa en Maas)

Simpelveld
(Waterschap Limburg)

Garmerwolde
(Waterschap Hunze en
Aa's)

DUTCH AND EUROPEAN AMBITIONS

- Antibiotic resistance
- Nano particles
- Microplastics
- Sweeteners
- Biodiversity
- Climate change
-????



European Frame Work Directive

NL 100% energy neutral

NL 100% climate neutraal

NL 100 % circular

** DRAFT European Wastewater Directive*

WWTP's > 150.000 i.e. 6 mg/l N and 0,5 mg/l P

WWTP's > 200.000 i.e. 80% micro's

with intermediate targets in 2035 and 2040

Tertiary treatment will be mandatory in smaller agglomerations in areas at risk of eutrophication

100% energy neutral

program

Program Wednesday November 8th

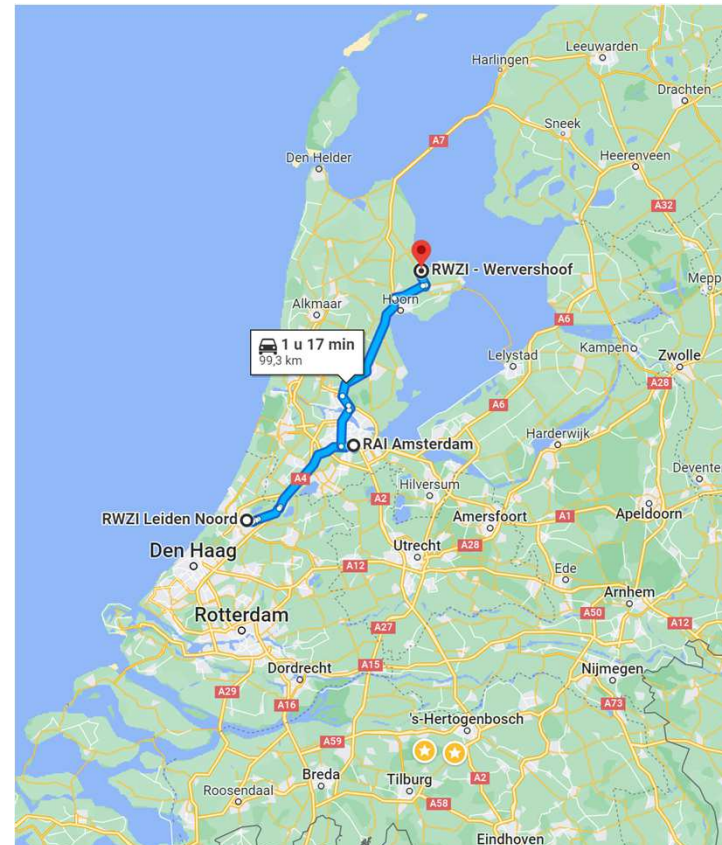
- 10.00 Opening Aquatech Expo
10.00 Registration with coffee and tea
10.30 **Opening and welcome – Cora Uijterlinde | STOWA**
- 10.45 **Session 1 - Tackling removal of micropollutants: policy meets practice**
Chair - Maarten Nederlof | Program Manager Implementation Demo's Dutch Water Authorities
- 10.50 The Dutch Approach – Oscar Helsen | Ministry of Infrastructure and Environment
11.10 Progress Full-scale Implementation Removal of Micropollutants @ NL - Maarten Nederlof
11.30 Full scale implementation of PACAS @ wwtp's Leiden Noord and Oijen – Paul Versteeg | Water Authority Rijnland and Robert Kras | Water Authority Aa and Maas
11.50 Implementation of Activated Carbon: Lessons Learned, Knowledge Gaps and Future Research Ad de Man | Water Authority Limburg and Chair Work Force Implementation Activated Carbon @ NL
- 12.15 **Lunch Break**
- 13.15 **Opening afternoon sessions: Overview Performances Innovative Technologies Activated Carbon and Non-Fossil Alternatives - Mirabella Mulder | STOWA / Mirabella Mulder Waste Water Management**
- 13.40 **Session 2 – Innovation in Powdered Activated Carbon (PAC)**
Chair – Roger Vingerhoeds | Water Authority Brabantse Delta
- 13.45 Pilot Powdered Activated Carbon Nereda Activated Sludge – Sandra Malagon | Water Authority Limburg
14.00 Pilot PAC dosage and Cloth Filtration – Arnoud de Wilt | Royal Haskoning DHV
14.15 Using Non-Fossil commercially available PAC – Joost van den Bulk | Tauw
14.25 Measurement of PAC in effluent and effect of PAC on digestion – Herman Evenblij | Royal Haskoning DHV
- 14.40 **Coffee Break**
- 15.10 **Session 3 – Innovation in Adsorption onto New Fossil Free Materials**
Chair – Ruud Schemen | Water Authority de Dommel
- 15.15 Pilot Zeolites Adsorption– Jan Peter van der Hoek | Delft University of Technology
15.30 Pilot DEXSORB (Cyclodextrines) Adsorption – Jaïr Dan | Witteveen+Bos
- 15.45 **Session 4 – Innovation in Granular Activated Carbon (GAC)**
Chair – Manon Bechger | Waternet (Water Authority Amstel, Gooi and Vecht)
- 15.50 Pilot Upflow GAC (CarboPlus and DynaCarb)– Alexandra Deeke | Water Authority de Dommel
16.15 Pilot BODAC (Discontinuous BioGAC)– Astrid Mous | WLN
16.30 Pilot Continuous Bio-GAC – Hans Wouters | Brightwork
- 16.45 **Closing day 1 and preview program day 2 – Cora Uijterlinde | STOWA**

Program Thursday November 9th

- 10.00 Opening Aquatech Expo
10.00 Registration with coffee and tea
- 10.30 **Opening and welcome day 2 and session 5 – Full-scale Implementation of Ozone in the Netherlands**
Mirabella Mulder | STOWA / Mirabella Mulder Waste Water Management
- 10.35 Full scale implementation of Ozone @ wwtp's Houten and Wervershoof – Marlies Verhoeven | Water Authority Stichtse Rijnlanden and Maaik Hoekstra | Water Authority Hollands Noorderkwartier
- 11.00 Implementation of Ozone: Lessons Learned, Knowledge Gaps and Future Research
Ruud Schemen | Water Authority de Dommel and Chair Work Force Implementation Ozone @ NL
- 11.20 **Overview Performances Innovative Technologies day 2: Combinations with Oxidation**
Mirabella Mulder | STOWA / Mirabella Mulder Waste Water Management
- 11.45 **Session 6 – Innovation in Combinations of Ozonation and PAC**
Chair – Robert Kras | Water Authority Aa and Maas
- 11.50 Pilot O3-STEP – Manon Bechger | Waternet (Water Authority Amstel, Gooi and Vecht)
- 12.05 Pilot PAC-O3 – Laura Piai | Royal Haskoning DHV
- 12.20 **Lunch Break**
- 13.15 **Session 7 – Innovation in Combinations of Ozonation and Biological Degradation**
Chair – Robert Kras | Water Authority Aa and Maas
- 13.20 Do's and Dont's in Implementing Ozone: Minimization of byproducts and bromate formation
Arnoud de Wilt | Royal Haskoning DHV
- 13.30 Pilot MicroForce – Nelis de Rouck | PureBlue
- 13.45 Pilot B-O3 – Arnoud de Wilt | Royal Haskoning DHV
- 14.00 **Session 8 – Effects of Implementing Enhanced Removal of Micropollutants on Water Quality**
PFAS and Antibiotic Resistance Chair – Bert Palsma | STOWA
- 14.00 Do's and Don'ts in Sampling and Analysis to Determine Removal Performances – Bert Palsma | STOWA
- 14.20 Effects of Implementing Enhanced Removal of Micropollutants on Antibiotic Resistance
Imke Leenen | H2Oké
- 14.40 Effects of Implementing Enhanced Removal of Micropollutants on PFAS – Anja Derksen | Ad Eco Advies
- 15.00 **Coffee Break**
- 15.30 **Session 9 – Innovation in Combinations of Oxidation and Filtration and Natural Systems**
Chair – Bernadette Lohman | Water Authority Zuiderzeeland
- 15.35 Quick scan Natural Systems – Mirit Hoek | Tauw
- 15.55 Pilot Ozonation and Ceramic Filtration - Martin Spruijt | PWN-T
- 16.15 Pilot Nanofiltration and UV-treatment – Tom Weijtmans | Water Authority Aa and maas
- 16.35 **Closing of the event – Cora Uijterlinde | STOWA**
- 16.45 **Drinks and Bites**

Bus Trip Friday November 10th

9.30 – 17.00 PACAS WWTP Leiden Noord
and Ozone plant WWTP Wervershoof





Thank you for your attention!

www.stowa.nl/ipmv

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Cora Uijterlinde – STOWA uijterlinde@stowa.nl

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