



Full scale implementation of PACAS

At WWTP Oijen + Leiden, November 8th 2023

Waterboards in the Netherlands

WATERBEHEER 21 Waterschappen

2023



21 Regional Water Authorities in the Netherlands

Nr 11 = Rijnland

Nr 19 = Aa en Maas

WWTP Oijen

Waterboard Aa en Maas

- 7 municipal WWTP's
- At 3 WWTP's plans for Removal of Micropollutants
 1. Oijen : PACAS
 2. Dinther : PACAS + (demo) Ozon
 3. Vinkel : PAC + filtration

WWTP Oijen

- 2 aeration tanks (carrousel)
- 12 clarifiers
- Capacity : 360.000 p.e.
- Influent flow:
 - DWA : 1.600 m³/h
 - Max. RWA : 12.250 m³/h
 - Yearly average : 51.000 m³/d



PACAS- introduction

Powdered **A**ctivated **C**arbon in **A**ctivated **S**ludge

- Powder
- Dosed in the aeration tank
- Micropollutants adsorb to the PAC
- PAC builds up in the activated sludge (inert material)
- PAC removed from WWTP via waste sludge (same SRT as sludge)
.... digestion... and incineration...
- PACAS:
 - Relatively simple and robust
 - Experience: Good removal efficiency
- Equipment:
 - PAC-storage silo (80 m³)
 - Dosing installation → PAC slurry

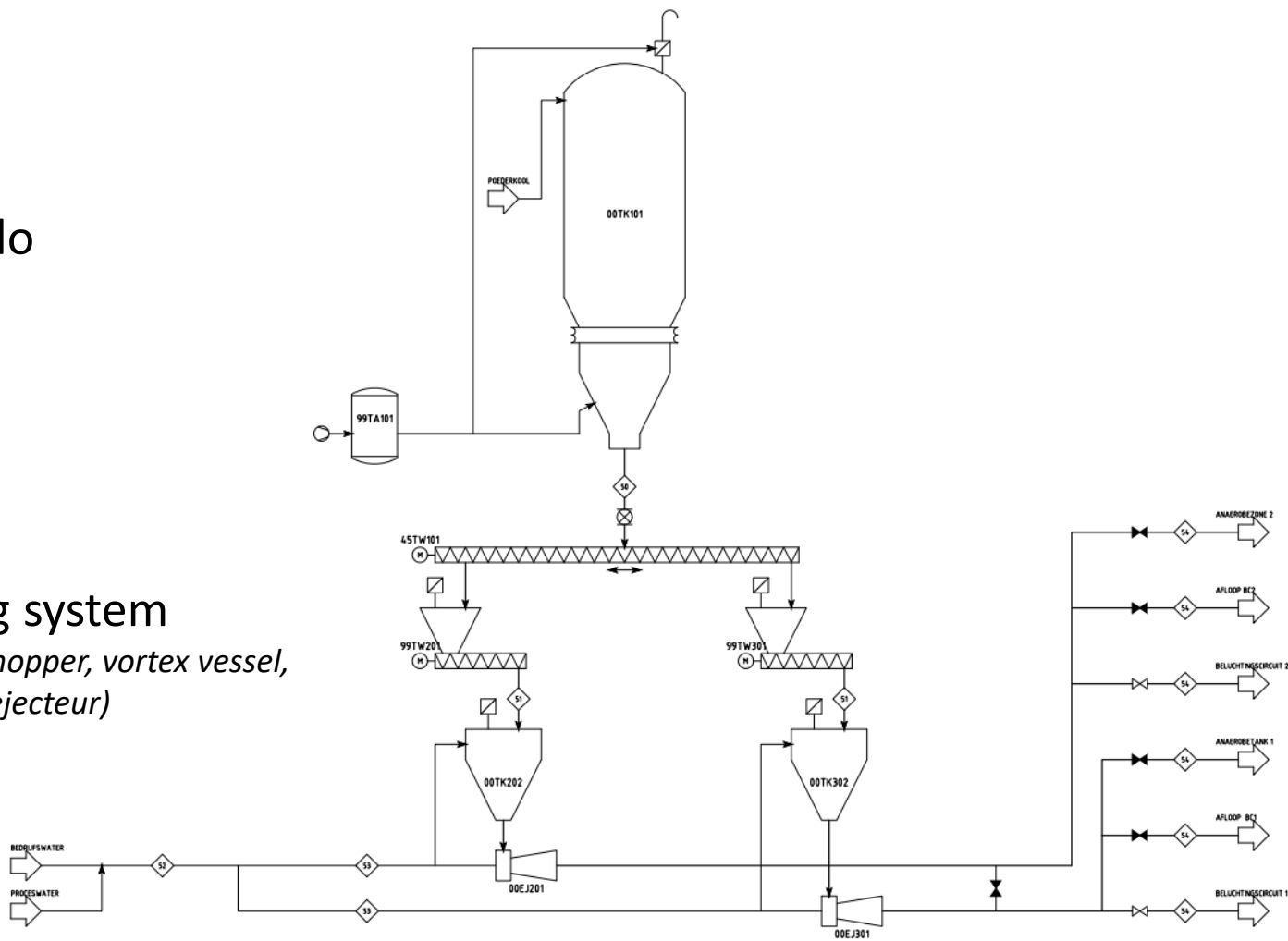


Werken met water. Voor nu en later.

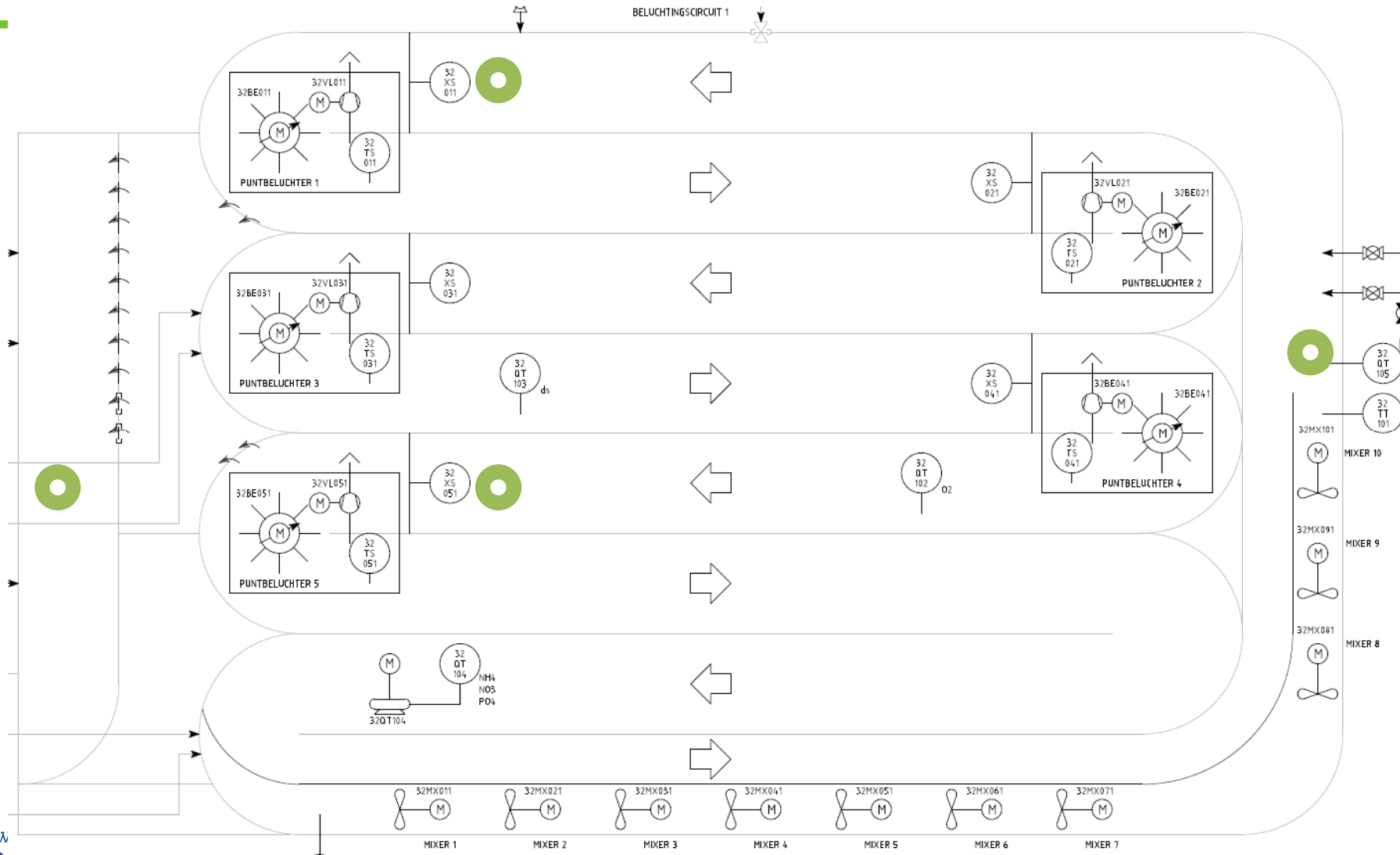
PFD PACAS installation

PAC Silo

Dosing system
*(screws, hopper, vortex vessel,
ventury/ejecteur)*

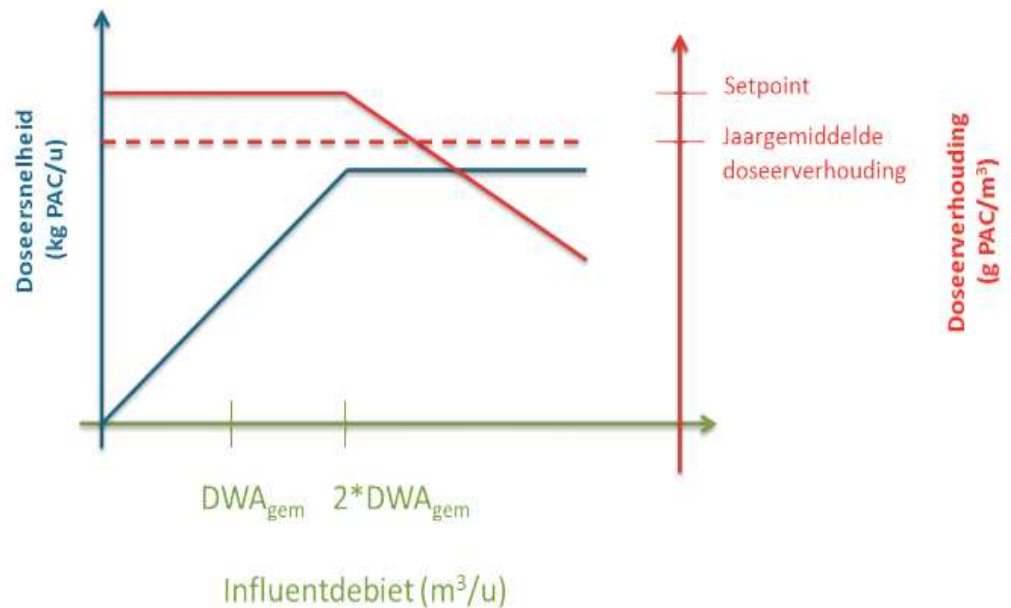


4 Dosing points



PACAS Oijen

- Full-scale installation
- PAC-dosing in both AT's
- 4 dosing points in each AT
(begin, half-way (2x), end)
- Dosing range: 5 - 25 mg PAC /liter influent
(40.000 m³/d @ 15 mg/l → 600 kg/d PAC)
- Dosing is proportional to influent flow
 - Until 2 x DWA
 - 85% yearly flow (15% “lower” PAC conc.)



PACAS Oijen, start up period

End 2022 : Commissioning, functional test

Jan 2023 : Start PAC-dosing (5 mg/l)

April 2023 : Stop PAC-dosering, because of “technical problems”....

Existing (effluent) water-system for preparation PAC-slurry...

- Contaminated / plugged valves, filters etc.
- Large fluctuations in Pressure and Flow

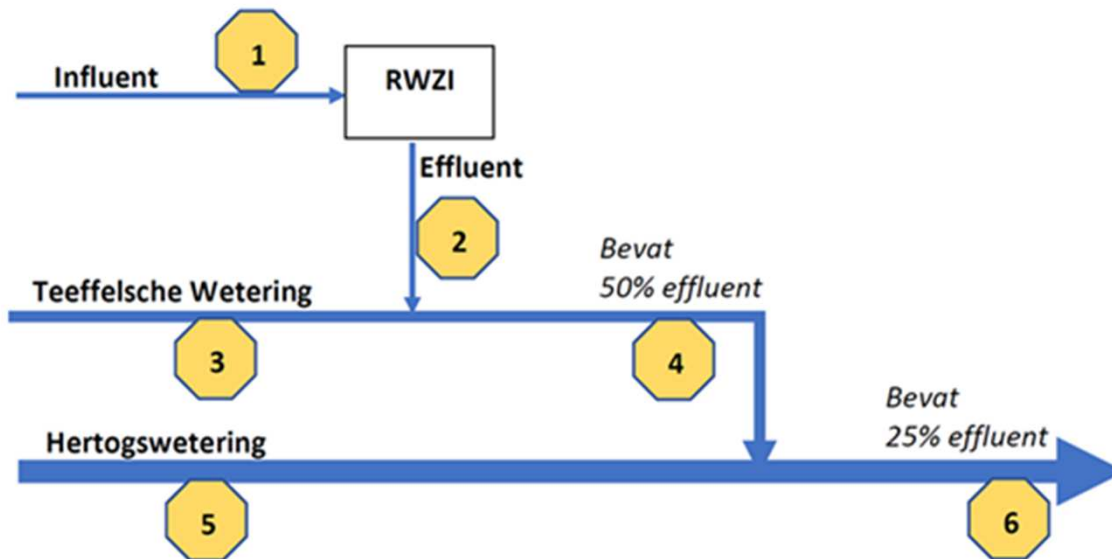
Sept 2023 : Re-start PAC-dosing (5 mg/l)

Actually no results available of PACAS...

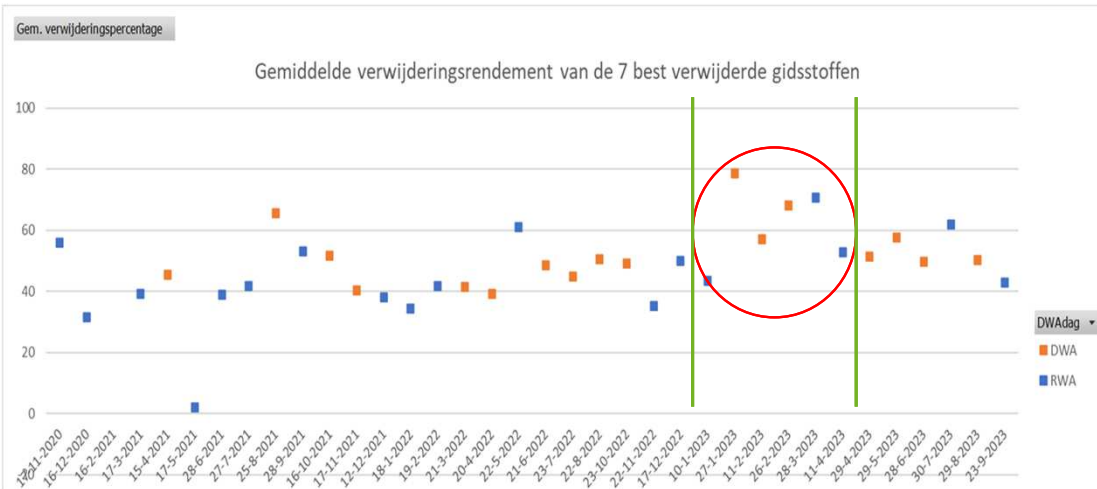
... but we have the reference situation (before PACAS)

Reference situation (before PACAS)

- Before PACAS start-up
- Extensive monitoringsprogram
- Period : nov 2020 - dec 2022 (2 years!)
- Sampling points : influent, effluent, surface water (4X)
- Analytical packages (374 components)
 - Guiding substances
 - Hormones, Medicines/ drugs
 - Pesticides, crop protection agents
 - X-ray contrast agents
 - Sweeteners
 - PFAS
 - Eco-toxicity
 - Metals
 - etc



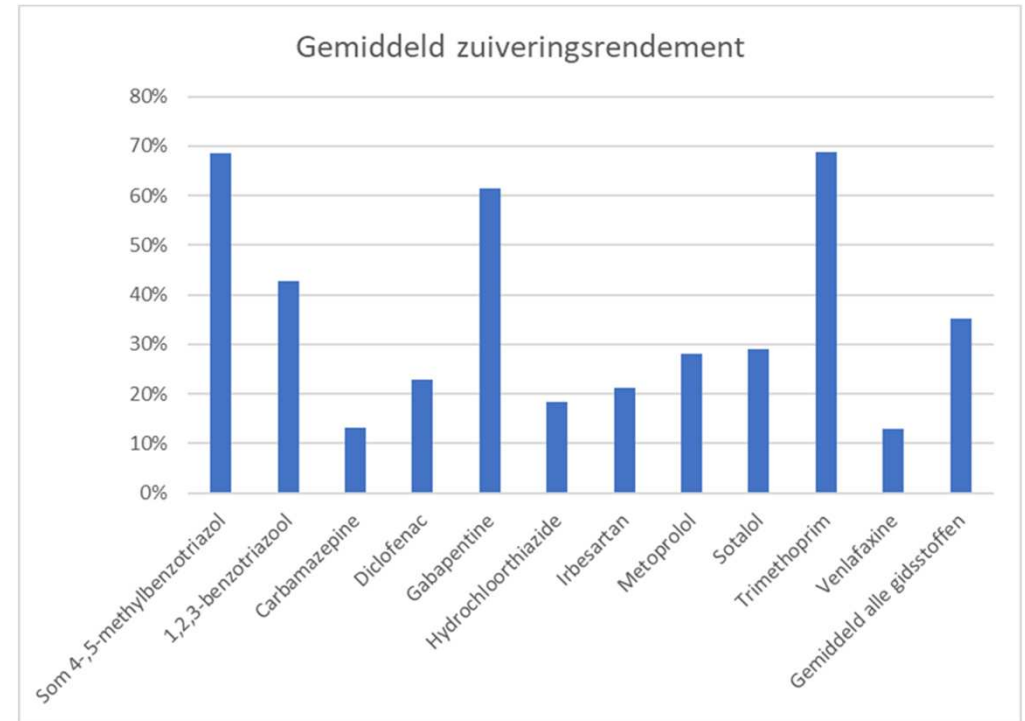
Reference situation: results/ conclusions (1)



Removal in WWTP (7 of 11 guiding substances)

- Range : 30-55%
- Average all days : 40% (n=23)
- Average DWA : 48% (n=10)
- Average RWA : 33% (n=13)

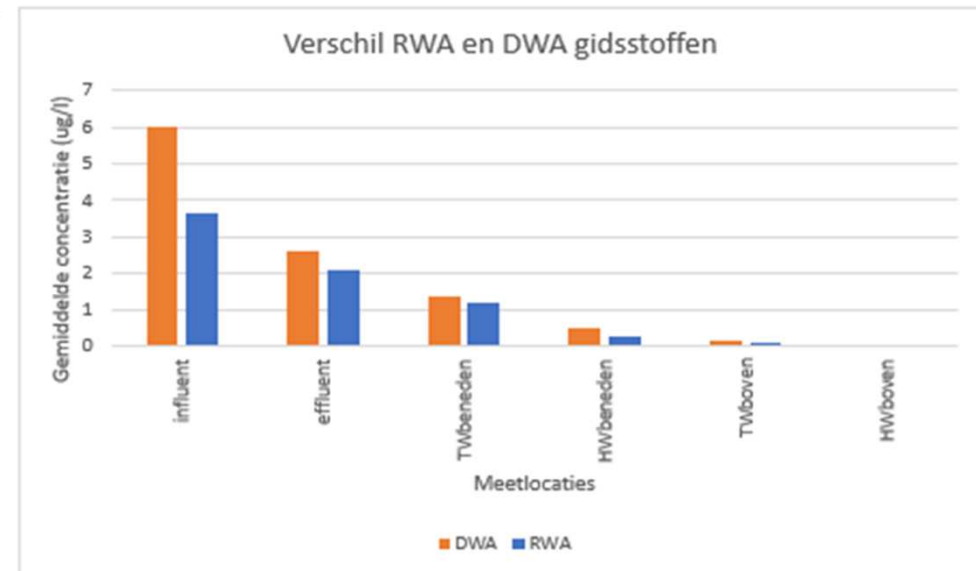
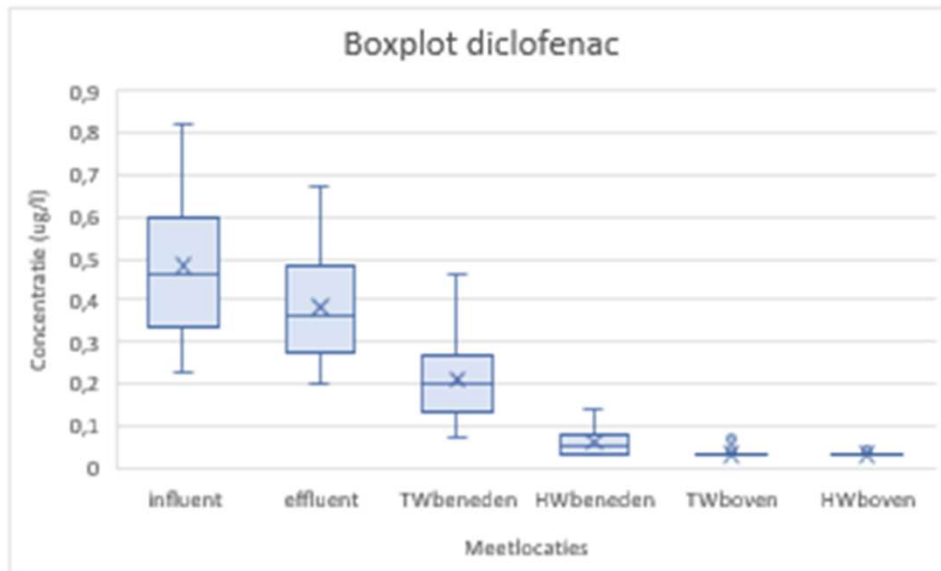
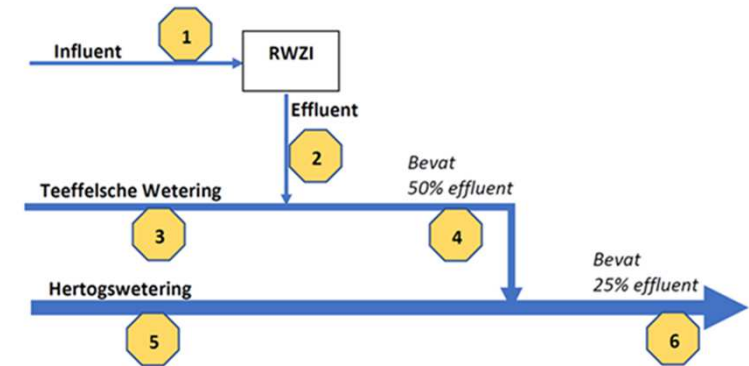
In red circle: Results during 5 mg/l PAC-dosing



Removal efficiency in WWTP of guiding substances

Reference situation: results/ conclusions (2)

- 374 components were analysed, several components were < detection limit
But for 63 components > 10% of the results (effluent + surface water)
> “detection limit” **and**
> “norm”
- Discharge of effluent has clearly negative effect on quality of surface water



Reference situation: results/ conclusions (3)

Discharge of effluent has clearly negative effect on quality of surface water

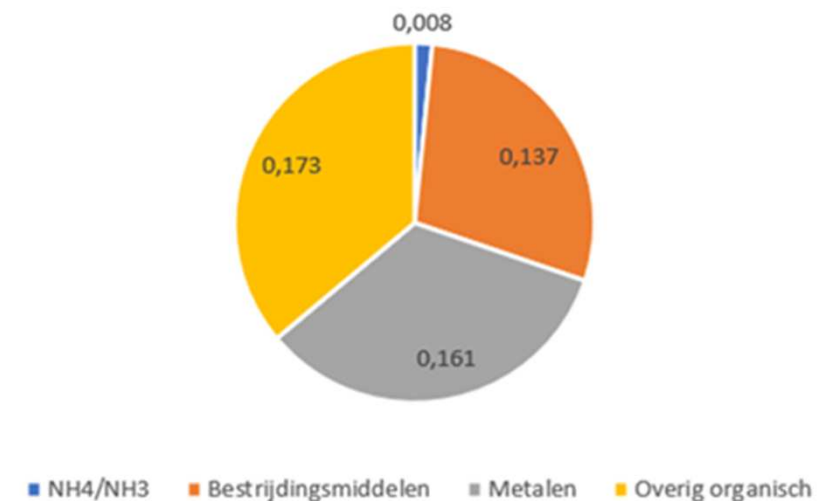
Toxicity (bio-assays, msPAF) of effluent and surface water downstream is **higher than KRW-goals** for good ecological status

Ecologische toestand	KRW-bescherming		KRW-herstel		
	Zeer goed	Goed	Matig	Ontoereikend	Slecht

Locatie	GR CALUX	Era CALUX	PAH CALUX	PXR CALUX	Microtox	Daphniatox
Effluent	34,10	15,72	193,73	35,89	0,04	0,02
TWbeneden	19,60	5,24	211,67	20,59	0,03	0,02
HWbeneden	3,78	1,69	42,70	12,24	0,02	0,02
TWboven	4,24	0,90	59,04	9,24	0,02	0,02
HWboven	1,17	0,09	40,56	3,64	0,02	0,02
Blanco	12,46	1,32	133,48	13,42	0,02	0,02

Bio assays: average results (KRW classification)

Gemiddelde effluent msPAF verdeling



Multi Substances Potential Affected Fraction

PACAS

Powder Activated carbon in Activated Sludge

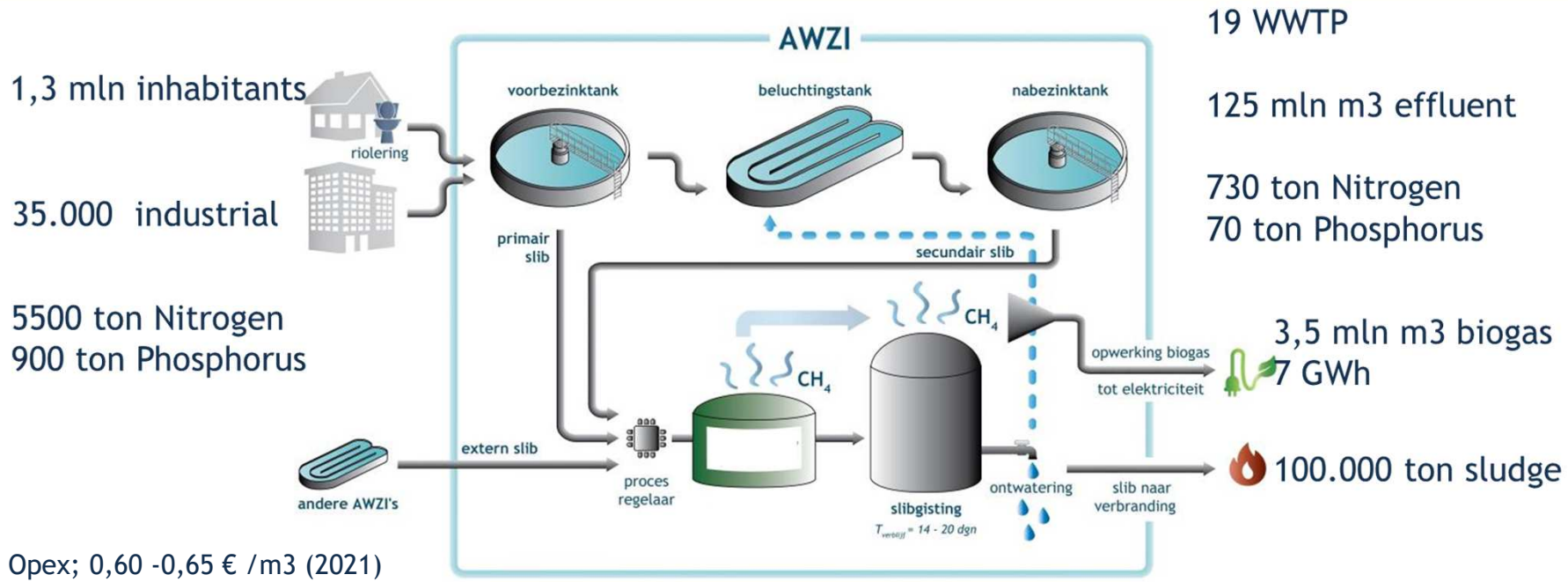
*WWTP Leiden-Noord
WWTP Oijen*



Hoogheemraadschap van
Rijnland



Waterauthority Rijnland WWTP (annual figures)



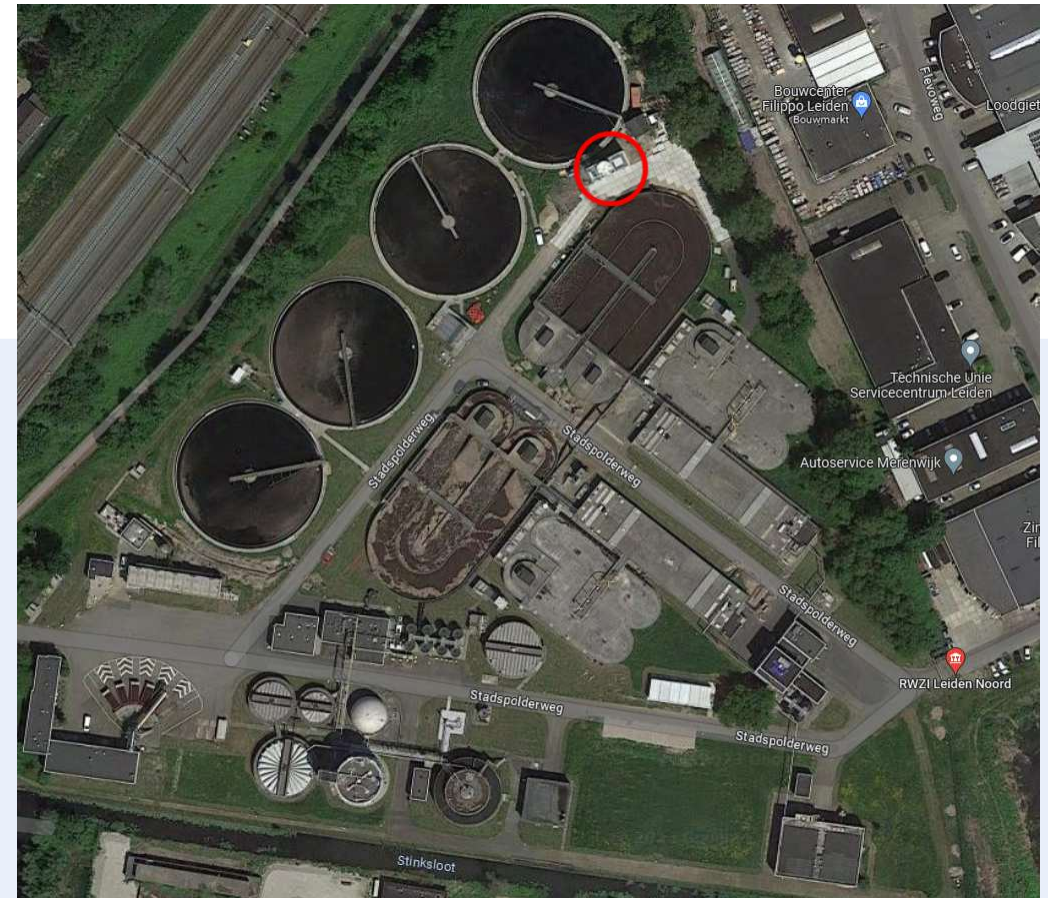
First full-scale PACAS Netherlands

WWTP Leiden Noord

- Capacity 140.000 p.e
- DWF; 1.900 m³/hr
- SWF; 4.900 m³/hr
- Sandfiltration for N- and P-removal

Requirements (year average);

- N-total 4,0 mg/l
- P-total; 0,4 mg/l



PACAS ; Treatment of 9 mln m³/yr

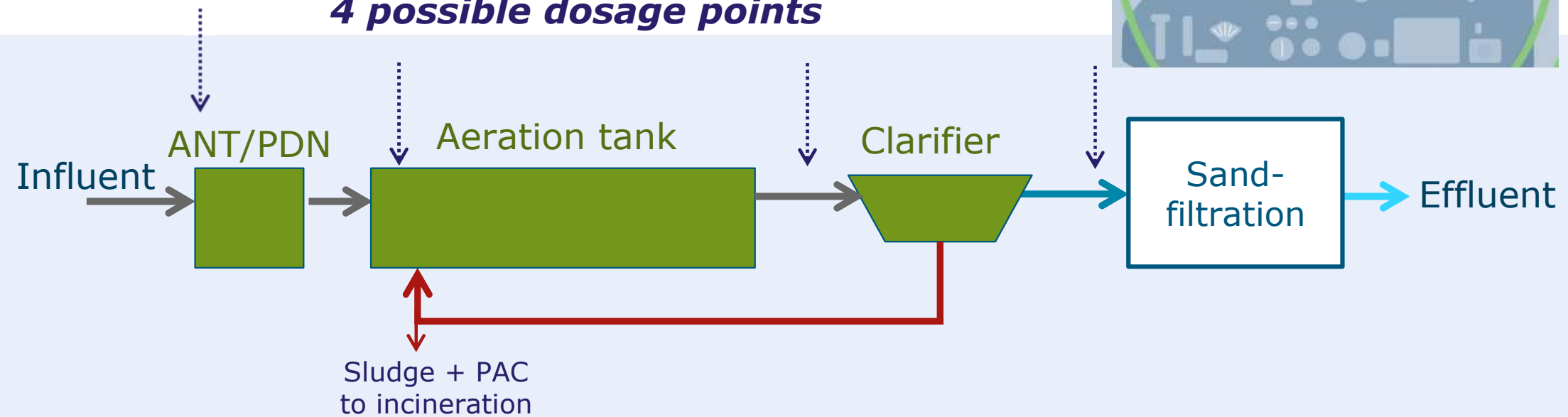
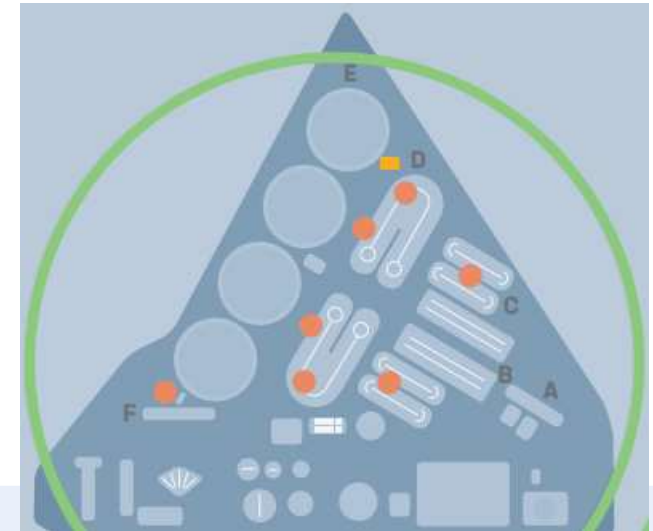
- Funding Min I&W; € 3,8 mln
- Construction costs € 2,4 mln
- Engineering costs € 0,8 mln.

Operational costs

- PAC-dosage; € 250.000,- (at 15 mg/l)
- Electricity ; € 50.000,-
- Operation ; 0,25 fte
- 0,05- 0,07 €/m³



PAC-dosage
Range 5–25 mg/l
4 possible dosage points



PAC used; Chemviron pulsorb wp235

Research program

01-2019; zero measurement WWTP and watersystem

02-2021 – 12-2023 Starting up + Determine dosage and dosing point,

02-2024 - 2031; operational phase;

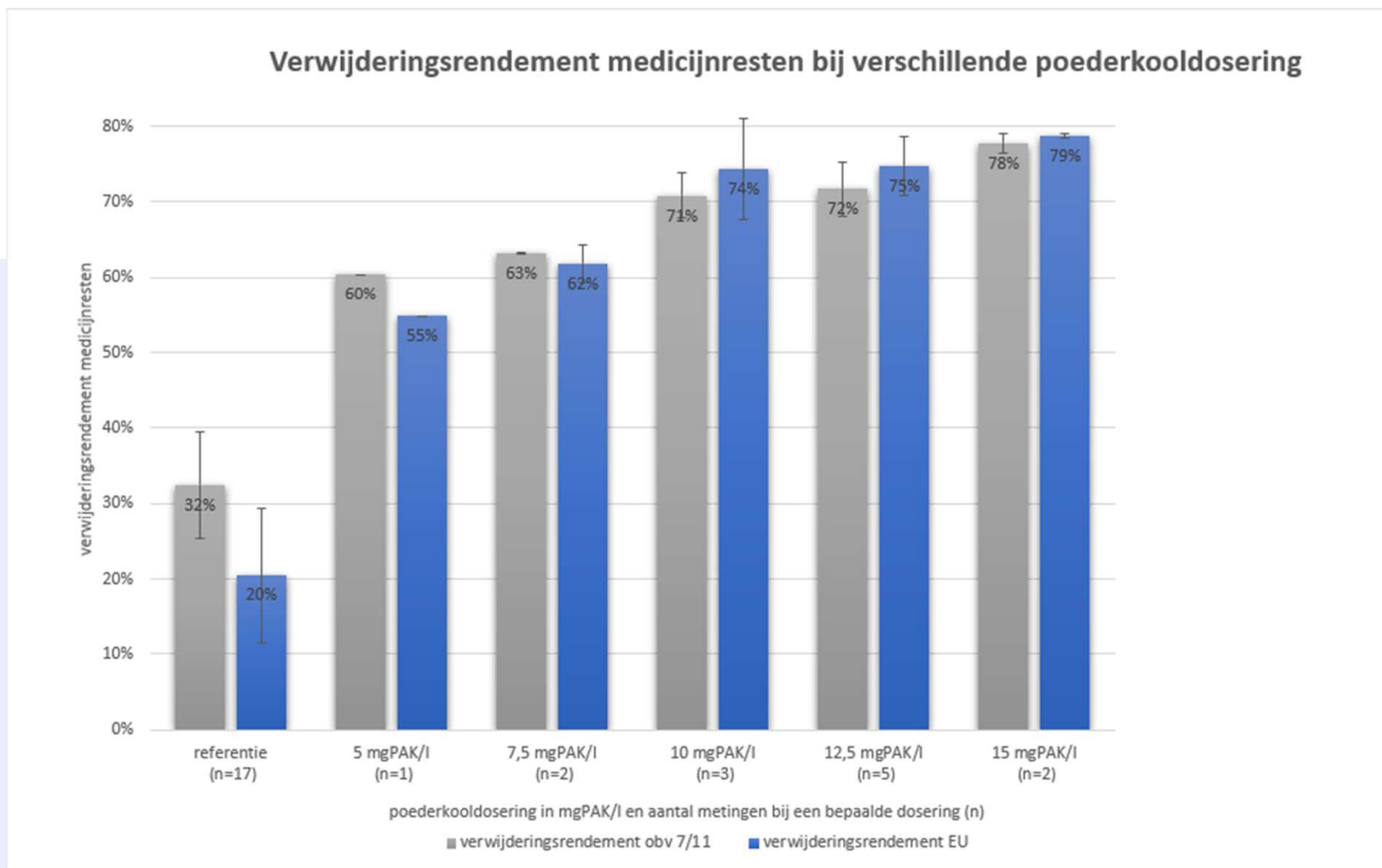
Requirement 70% removal for 7/11 guidance substances

determine side-effects N and P-removal, sludge handling and sludge

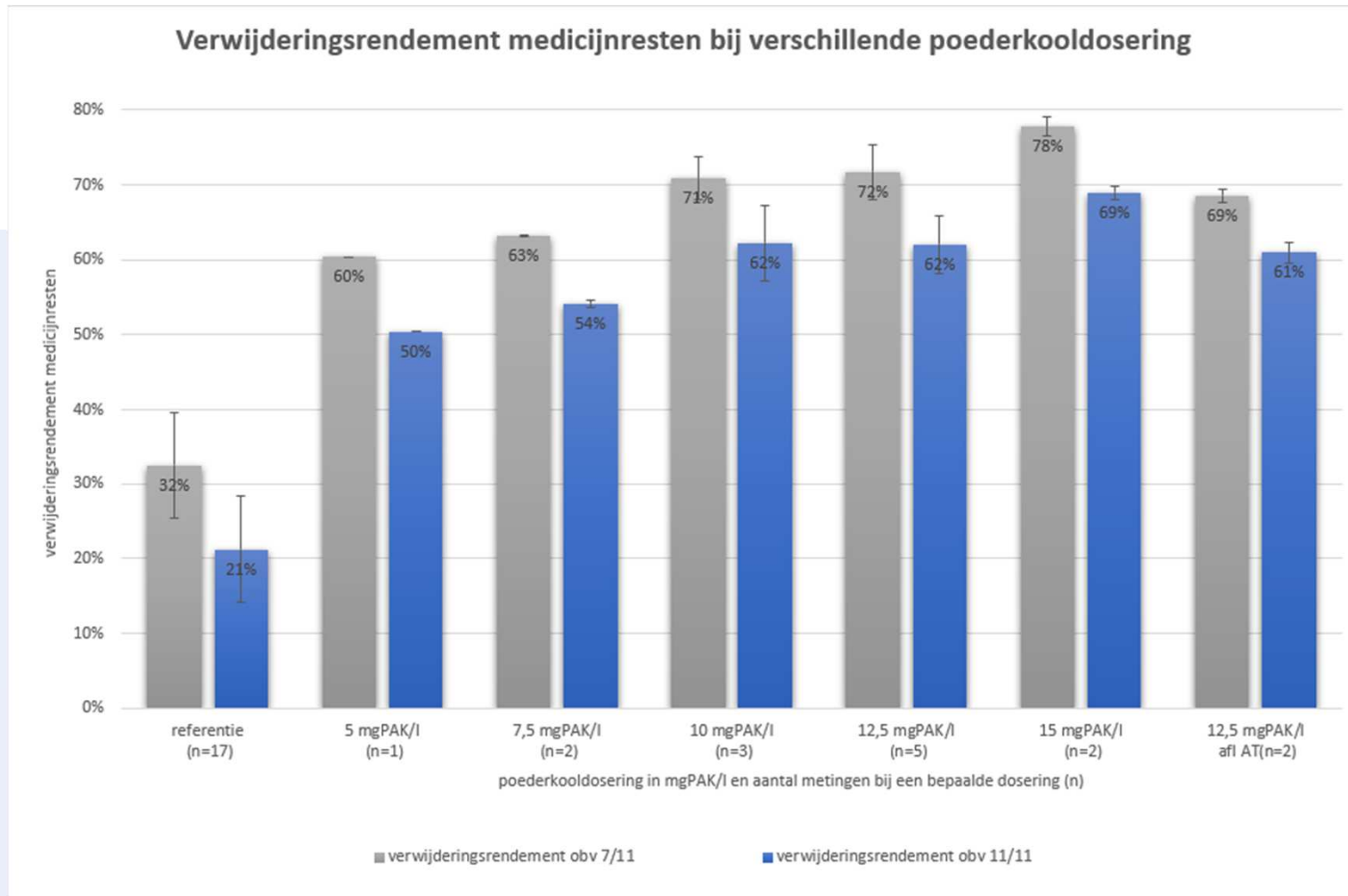
incineration (e.g. PFAS)



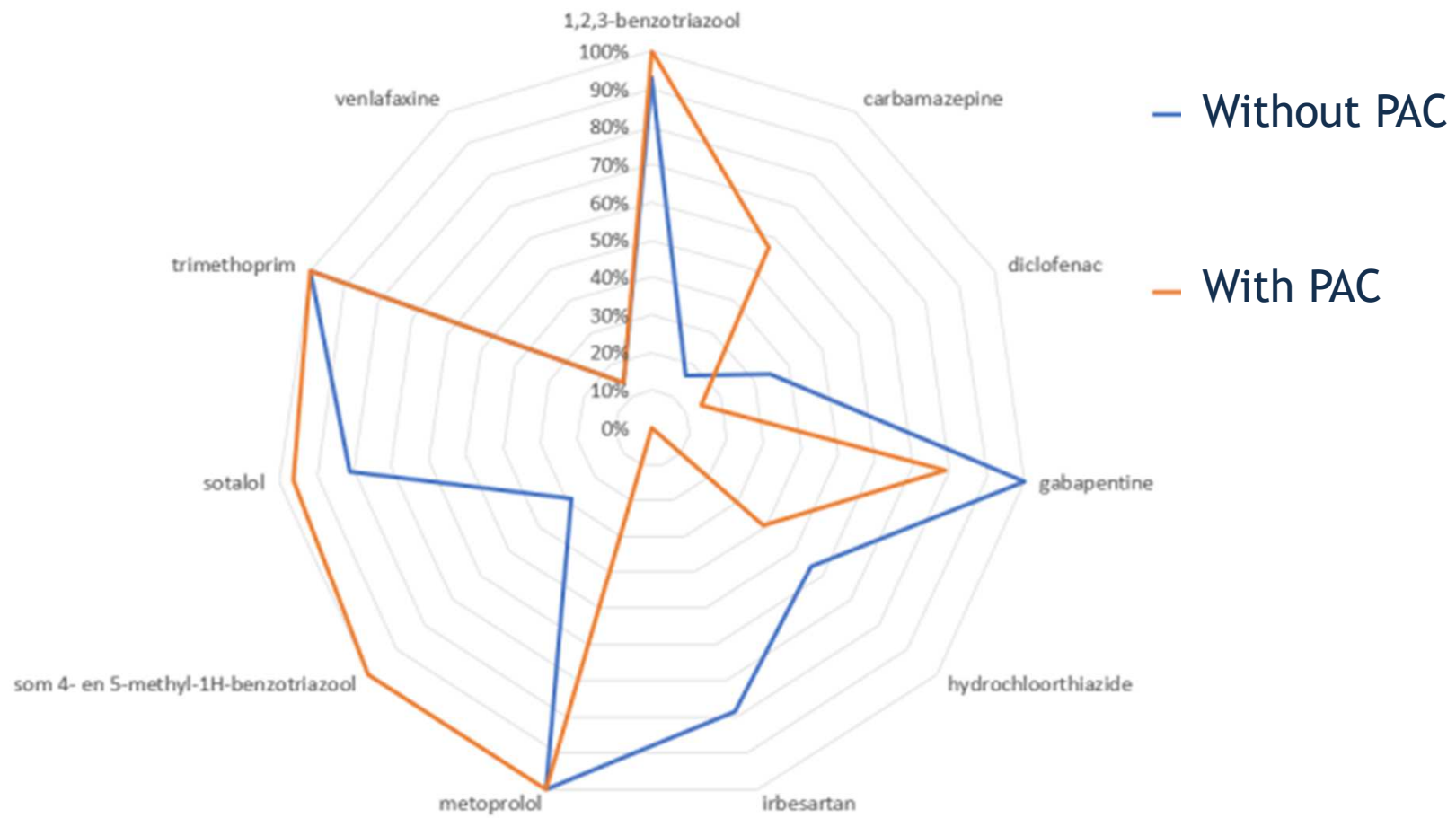
Removal efficiency



7 from 11 versus 11 from 11

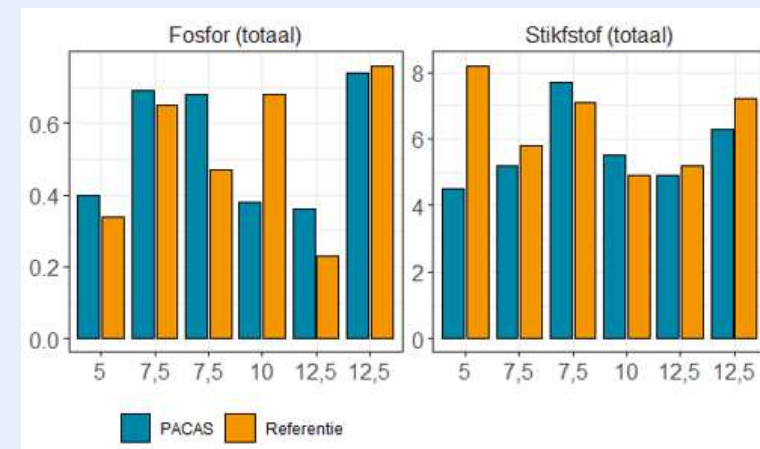
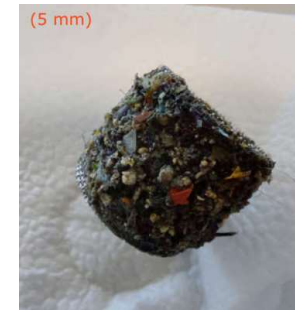
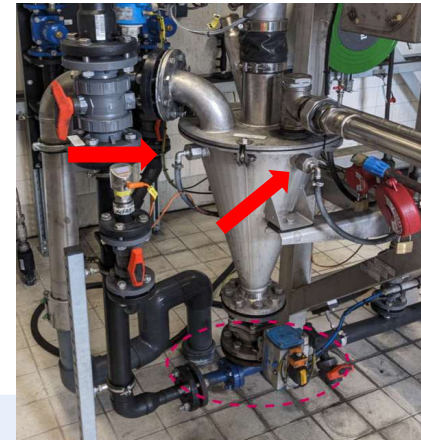


Gidstoffen die de basis vormen voor de rendementberekening



Lessons learned

- Due to fluctuations a PAC-dosage of 15 mg/l is probably required for 70% removal year round
- No effect of PAC-dosage (15 mg/l) on N & P removal
- No pfas removal observed (yet)
- Higher dosage (20 mg/l?) needed for EU 80% removal; maybe critical for N removal
- Critical; effluent filtration for slurring of PAC
- Critical; Sampling requires 72hr Dry weather condition



Future

WWTP Gouda;

Pilot-study Re-use of PAC-slurry
from drinking water company
(Dunea)





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

Why PACAS

- Removal of micropollutants ; mainly pharmaceutical residues, maybe X-ray contrast agents, maybe PFAS/PFOS
- No requirements; precautionary principle
- Low investment costs, low energy usage
- Easy to operate
- Part of the implementation programme