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Powdered Activated Carbon in Nereda WWTP Simpelveld

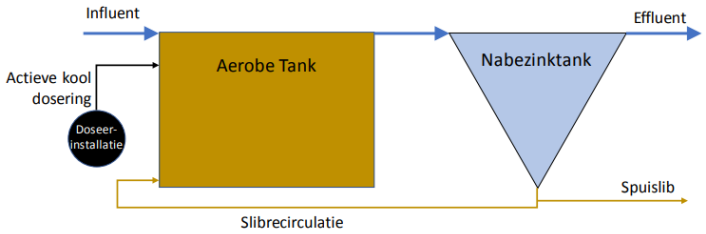
Sandra Malagón

November 8th 2023

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

1. Powdered Activated Carbon in Activated Sludge (PACAS)

- In activated sludge systems: proven technology. In NL 2 full-scale installations



- In Nereda: aerobic batch system with granular sludge : first application

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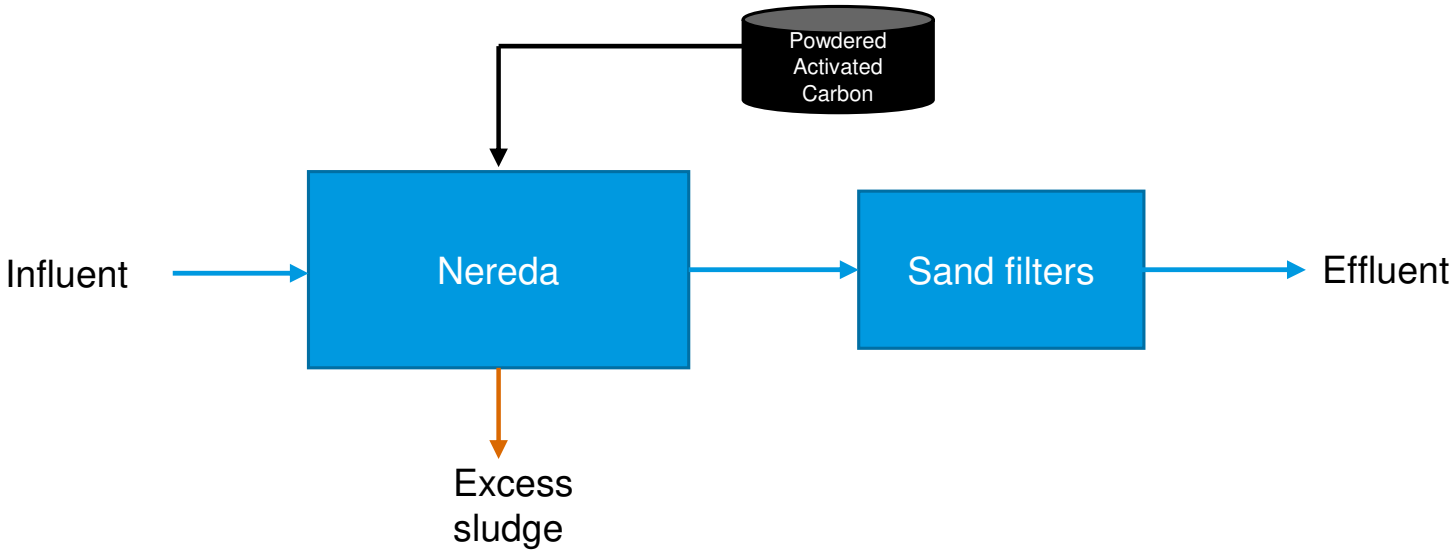
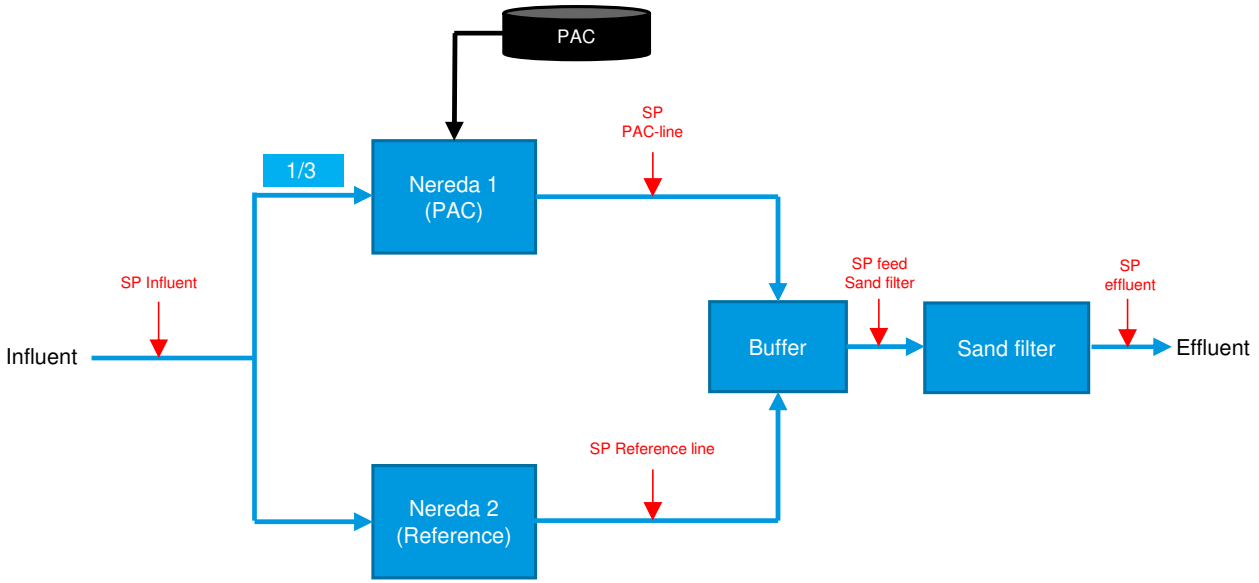
2. Technology

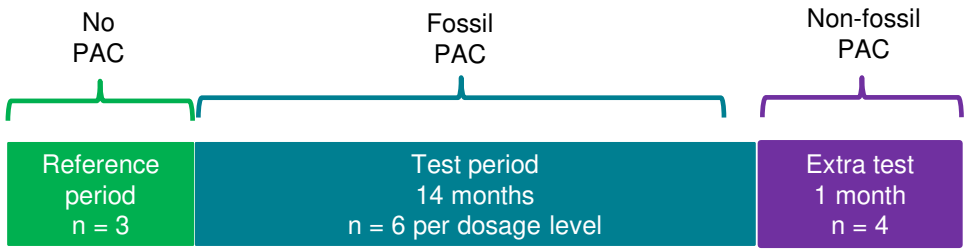
WWTP Simpelveld
12.600 PE á 150 TOD



3. Test Set-up

- Two Nereda reactors:
  - Nereda-1 (750 m^3) : Powdered Activated Carbon (PAC) line
  - Nereda-2 (1.500 m^3) : Reference line
- 1/3 of the influent is treated with PAC
- Sand Filtration
- Monitoring effluents Nereda (PAC and Reference line), feed to sand filters, effluent and sludge
- Increased dosage levels:
  - 5 - 10 - 15 - 20 mg PAC/l





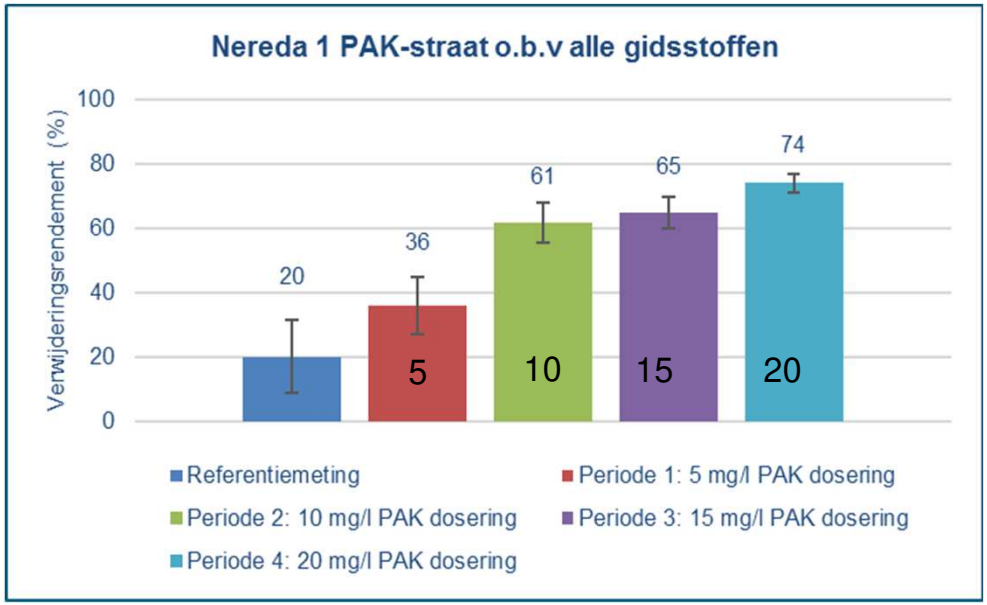
PAC in Nereda

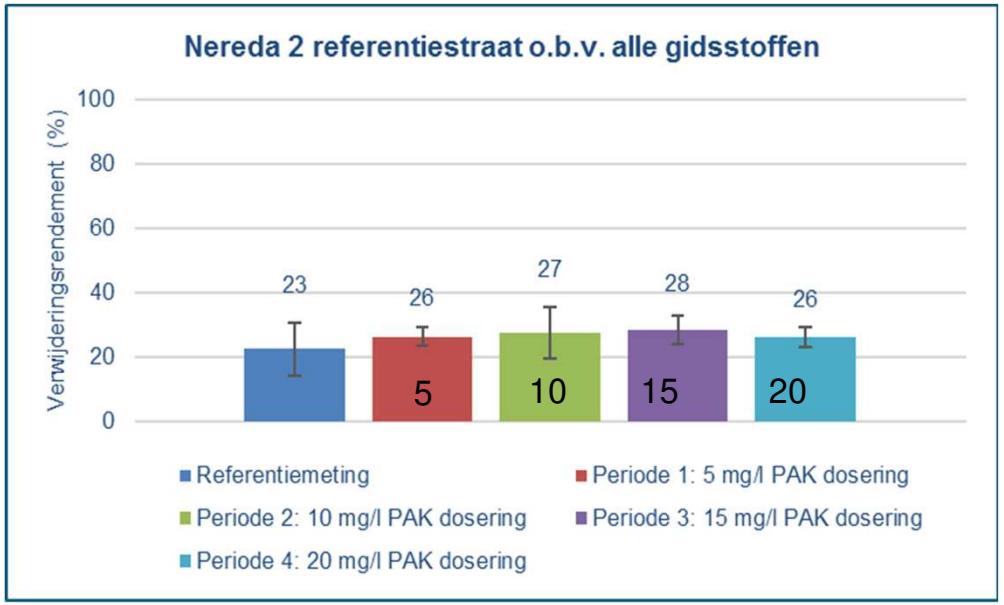
4. Dosage control

- Nereda® is a batch process: feeding/discharge, aeration and settling
- Dosage:30 minutes before the end of the aeration phase or if the ammonium concentration lower is than 5 mg/l
- Powdered Activated Carbon is dosed in a short time
- A ‘shot’ of activated carbon per batch, based on:
  - Amount of influent
  - The supply situation: dry weather/ rainy weather
- Powdered carbon dosing line is rinsed clean every time after dosing

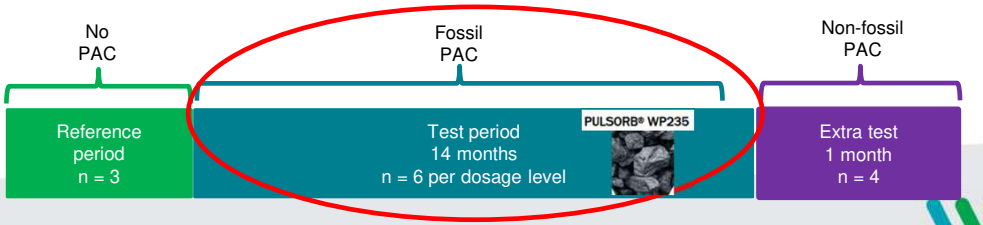
Results of removal of guide substances

based on 11 guide substances



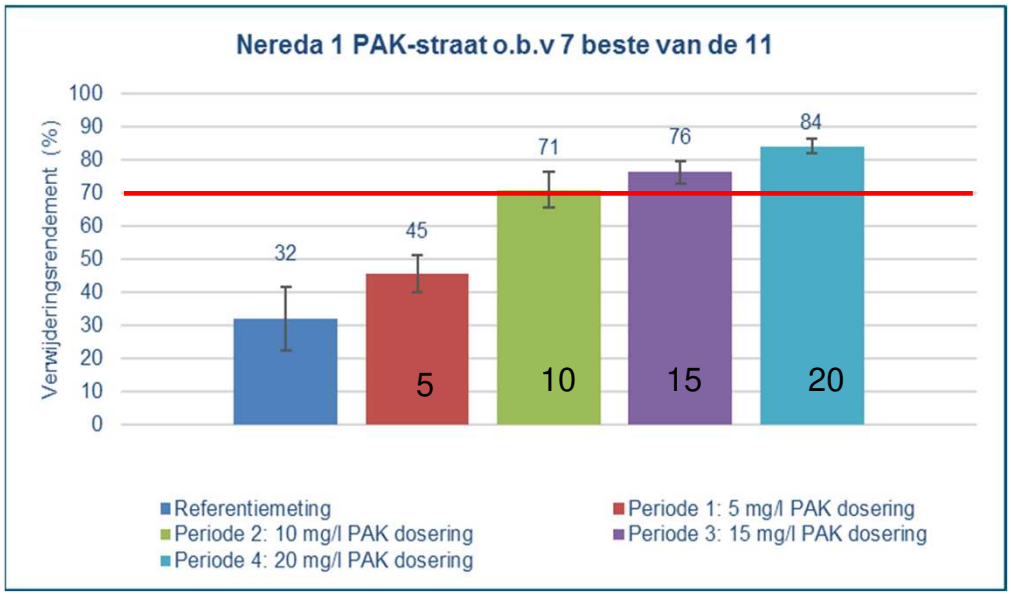


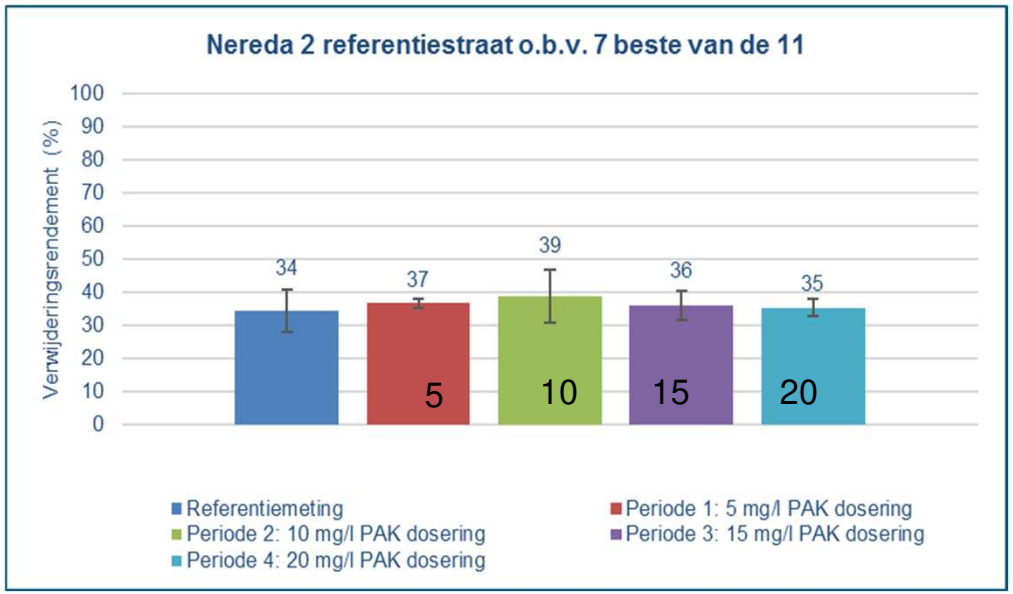
Guide substances: benzotriazool, carbamazepine, diclofenac, irbesartan, gabapentine, metropolol, hydrochloorthiazide, mixture of 4- en 5-methylbenzotriazool, sotalol, trimethoprim en venlaflaxine



Results of removal of guide substances

based on best 7 out of 11 guide substances





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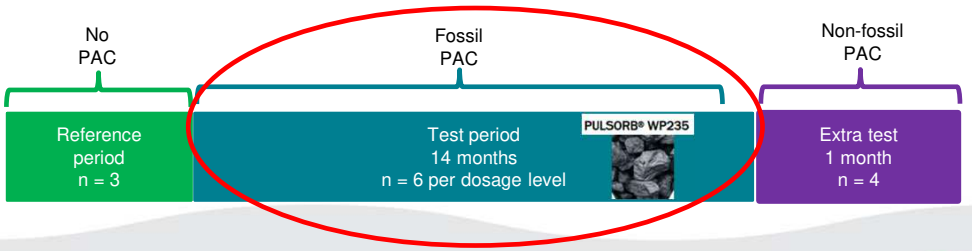
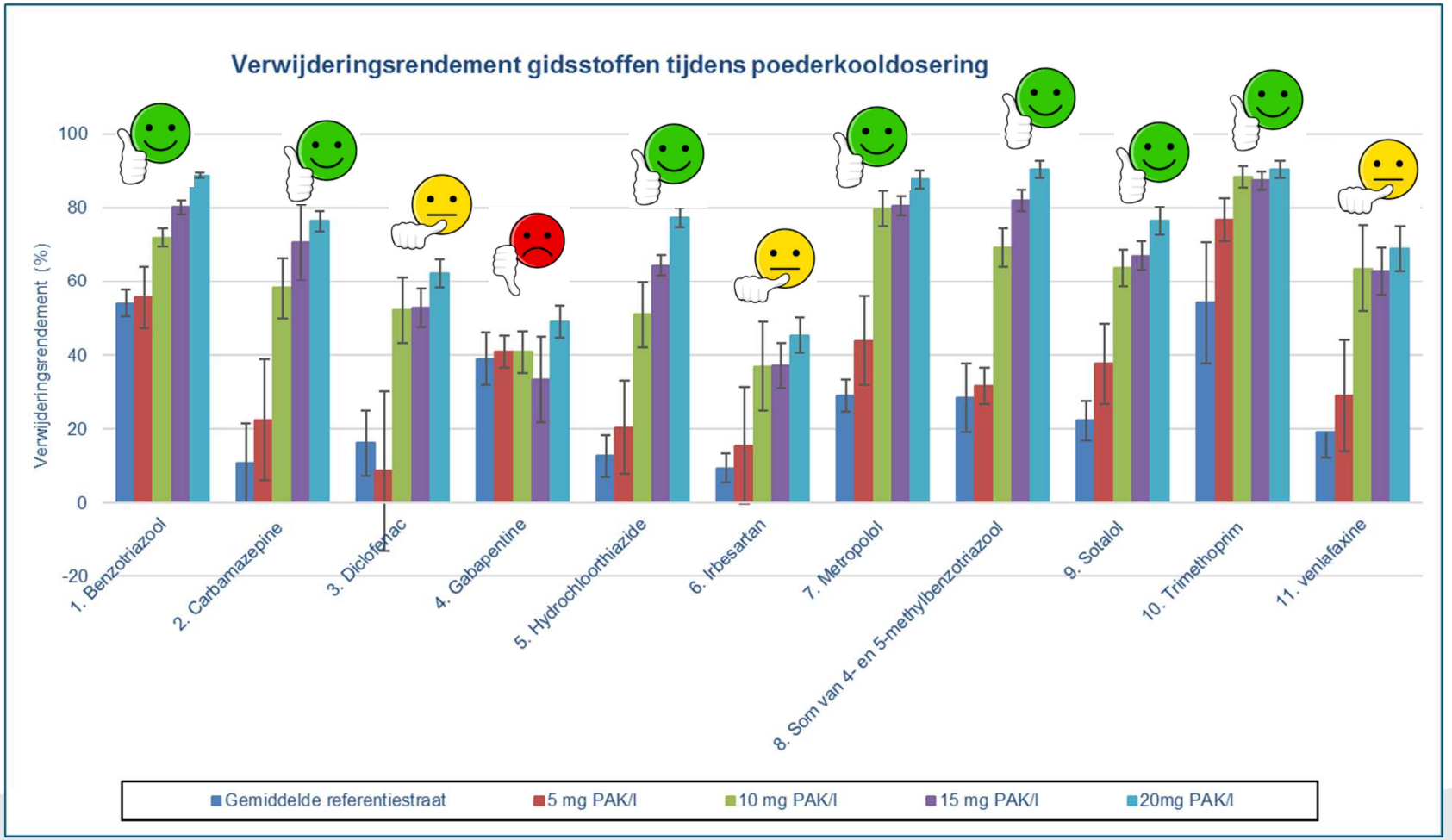


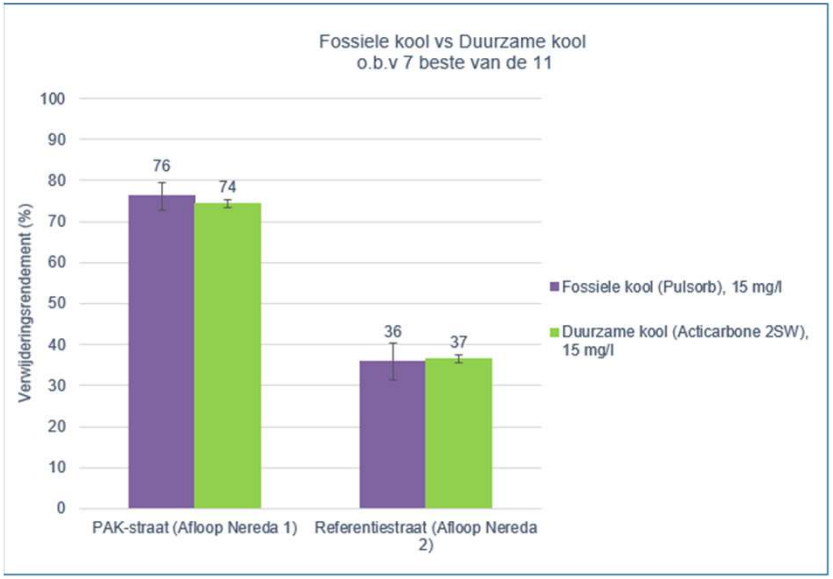
Average removal per guide substance



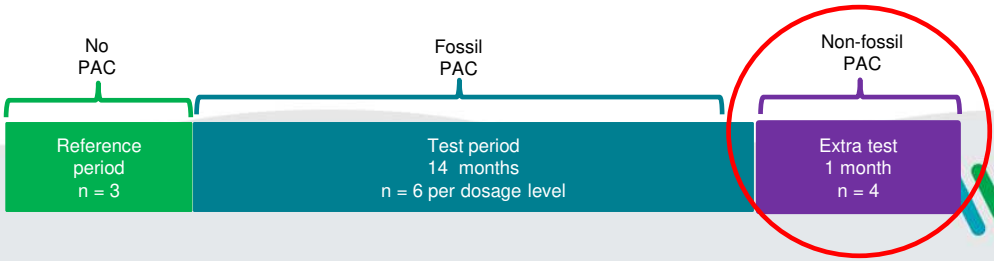
Removal of guide substances by non-fossil PAC

based on best 7 uit of 11 guide substances

- When dosing 15 mg/l of non fossil PAC, the same yield is achieved as with fossil PAC
- No washout of PAC with effluent
- Lower density



Verwijderingsrendementen bij gebruik van duurzame PAK vergeleken met fossiele PAK bij dosering van 15 mg/l. Aantal waarnemingen: bij fossiele kool n = 6 en bij duurzame kool n= 4 en referentiestraat (groen) gepresenteerd als gemiddelde van alle doseerperiodes.



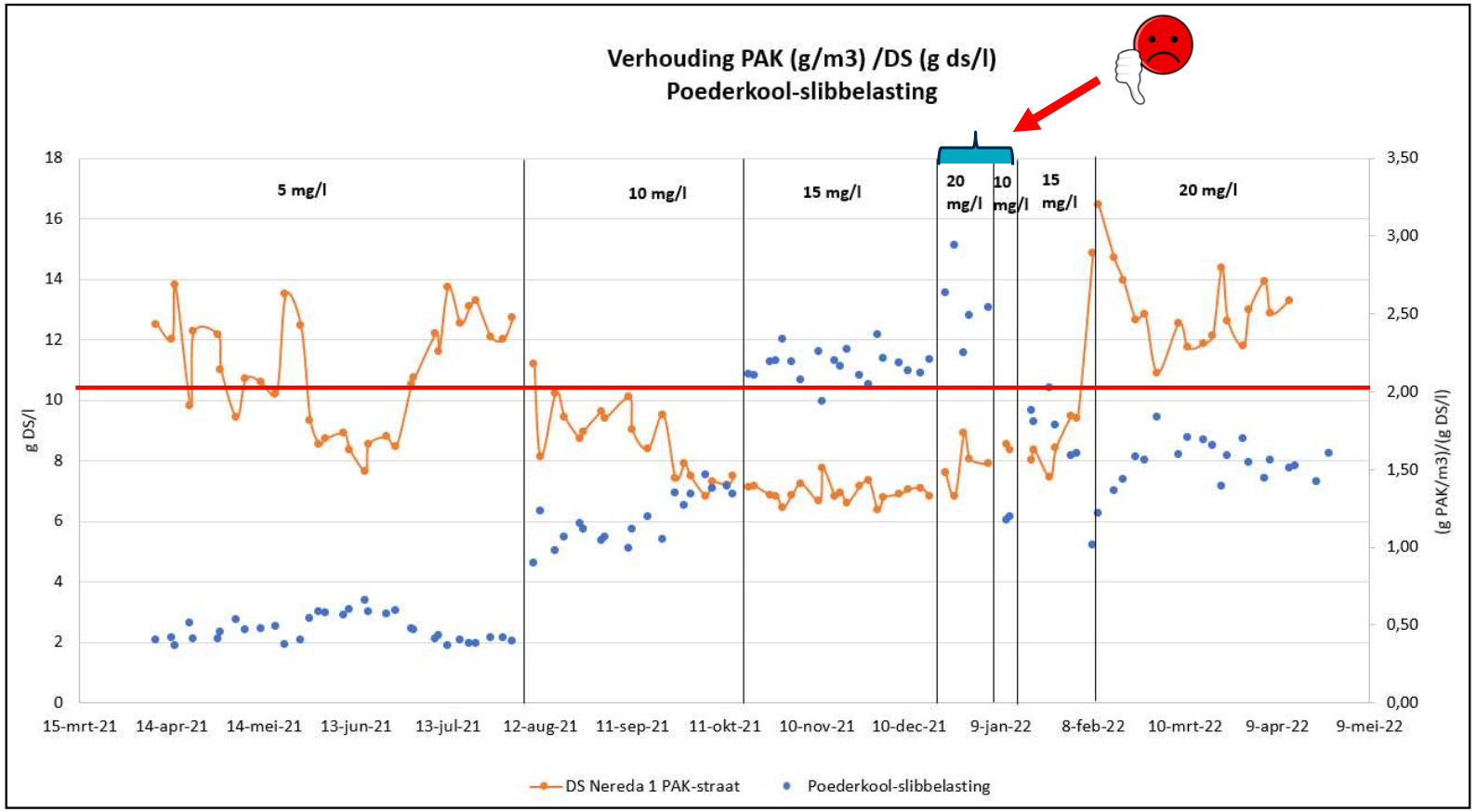
Removal efficiencies based on European Urban Wastewater Treatment Directive (UWWTD)

Dosage (mg PAC/l)	Average removal efficiency according to calculation rules new UWWTD when dosing fossil coal (%)
5	47
10	76
15	79
20	85

Verwijderingsrendementen, berekend volgens de voorgestelde rekenregels van de nieuwe Europese richtlijn stedelijk afvalwater (dit is exclusief het effect van zandfiltratie)

- The required removal = 80%
- Calculated over at least 6 substances of a total of 12 substances from 2 categories
- At a dosage of 15 mg PAC/l the required removal is achieved in Nereda
- Additional removal of micropollutants takes place in the sand filters

Activated Carbon/sludge ratio



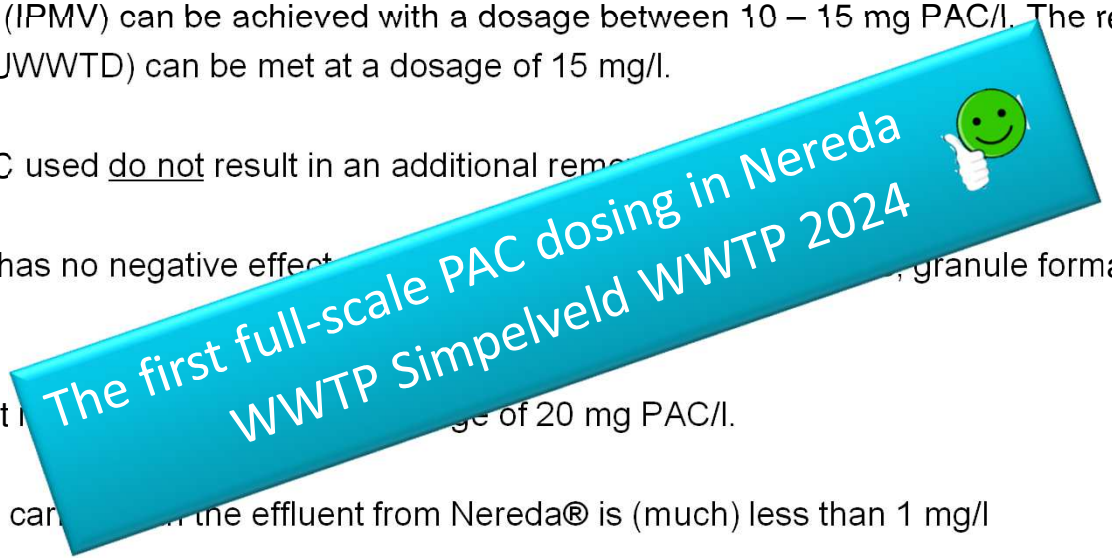
No washout of PAC in Nereda at an Activated carbon/sludge ratio of less than 2 g PAC/m3 influent / g ds sludge/l

Additional research

- **Bioassays:** With an increasing PAC dosage, the risks of the WWTP effluent for the receiving surface water decrease (50% at 20 mg PAC/l)
- **PFAS:** no additional removal of PFAS by dosing PAC (Pulsorb WP235)
- **Heavy metals:** no additional removal of heavy metals by dosing PAC (Pulsorb WP235)
- **Kaumera:** no effect of PAC dosing on Kaumera yield. Kaumera from PAC line has a darker color
- **Performance:** The removal efficiency of SS, P, COD and N are comparable for both Nereda reactors
- **Sludge :** Microscopic analyzes showed no physical effect on the granules.

Conclusions

- The required removal efficiency of 70% according to the performance requirements within the Dutch Innovation and Implementation Program (IPMV) can be achieved with a dosage between 10 – 15 mg PAC/l. The required removal according to the European Directive (UWWTD) can be met at a dosage of 15 mg/l.
- The dosage levels of PAC used do not result in an additional reme
- Dosing activated carbon has no negative effect , granule formation, settling properties or Kaumera yield.
- The toxicity of the effluent i ge of 20 mg PAC/l.
- The washout of activated car the effluent from Nereda® is (much) less than 1 mg/l
- At an activated carbon/sludge ratio up to 2 (g PAC/m^3 influent) / (kg ds/m^3 reactor volume Nereda), the activated carbon is incorporated into the granular sludge. At higher levels there is a risk of unwanted washout of PAC.
- Assuming a dosage of 15 mg PAC/l, the sludge production on the scale of Simpelveld will increase by 19 tons of ds/year, which is approximately 5% extra sludge production.



Summary Performances

	UNIT	PACAS	Ozone + Sand Filtration	PAC in Nereda
CO_2-footprint [1]	g CO_2/m^3	122	128	84-116*
Costs [1]	€/m^3	0,05	0,17	0,04 -0,05 *
Removal Efficiency Dutch guide substances[2]	%	70-75%	80-85%	70-75*

** Dosage between **10 and 15 mg/l**. This does not include the expected additional removal in sand filtration.*

*[1] 1 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*

[2] Overall Removal Efficiency of effluent wwtp to influent wwtp (including bypass post treatment) for 7 of 11 guide substances: benzotriazool, carbamazepine, diclofenac, irbesartan, gabapentine, metropolol, hydrochloorthiazide, mixture of 4- en 5-methylbenzotriazool, sotalol, trimethoprim en venlaflaxine 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 in stead of 70% in NL and different guide substances):

- PACAS will have a footprint of 160 g CO2/m3 and a cost level of € 0,08/m^3; no changes for ozone
- PAC in Nereda will have a footprint and costs which are slightly lower than PACAS

Thank you for your attention!

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Ministry of Infrastructure and Water Management

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Aquatech Amsterdam