



# AdOx – a next generation adsorption-oxidation process for removal of OMPs from municipal wastewater

Tackling Micropollutants in Wastewater – Approaches on Implementation and Innovation in Europe and the Netherlands

3-4 November 2021, Amsterdam, The Netherlands



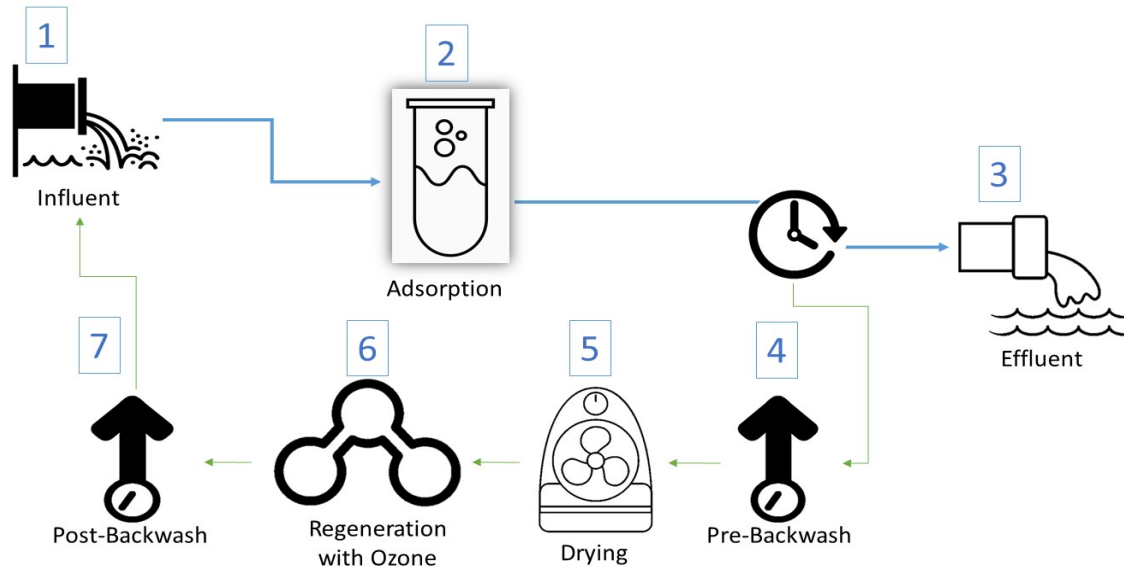
# AdOx principles

- Selective adsorption of OMPs by synthetic high-silica zeolites
- Use of zeolites as granules in a column as posttreatment
- Regeneration of exhausted zeolites with ozone gas on-site



# Innovations

- Use of zeolites as granules
- Regeneration of zeolites with ozone gas





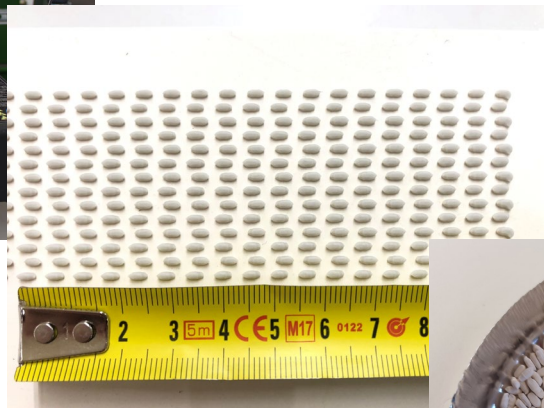
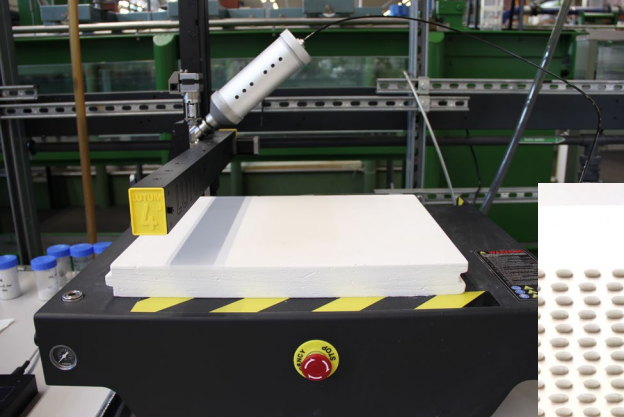
# Proof of principle

- Lab research:
  - Can we make granules from zeolite powders?
  - Do zeolite granules in a column set-up adsorb OMPs?
  - Can exhausted zeolite granules be regenerated with ozone gas?



# Granulation of zeolites

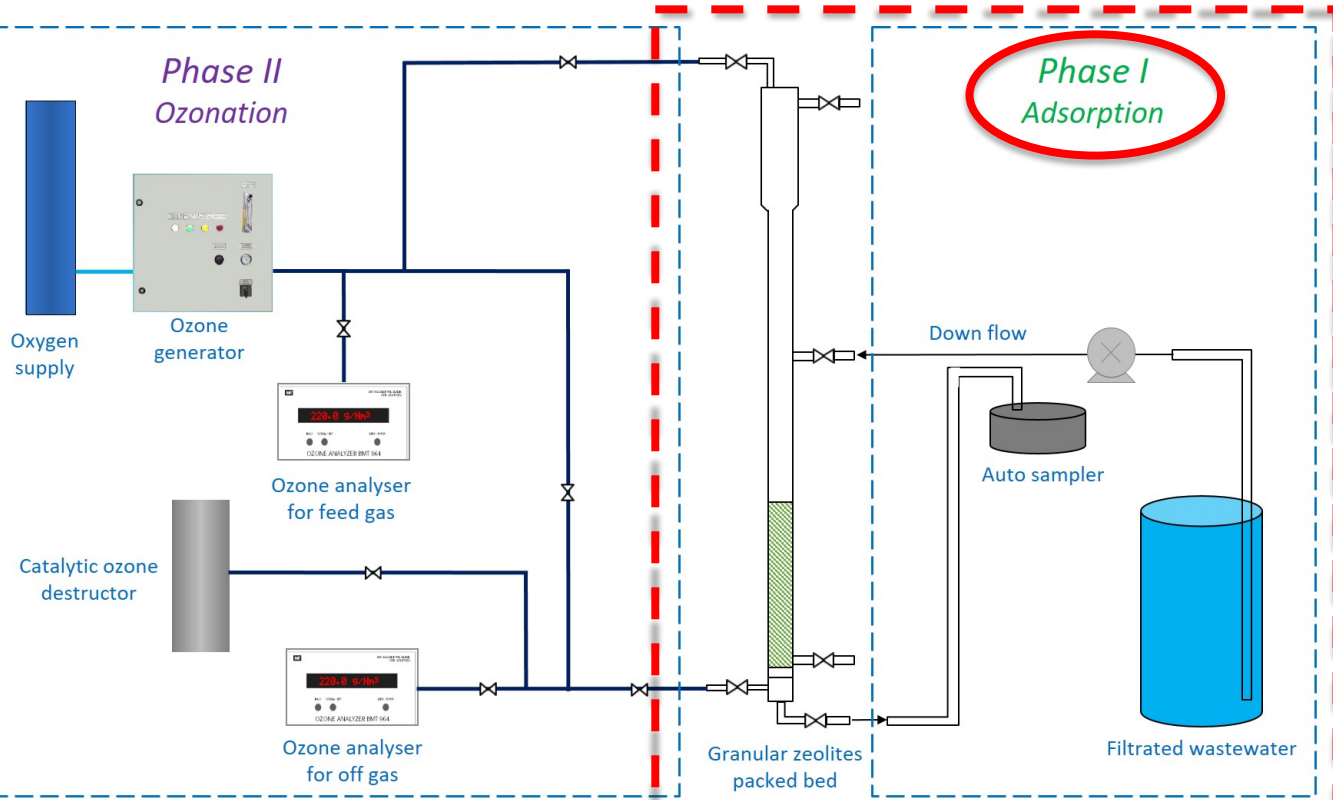
- 85% zeolite powder and 15% bentonite
- Mixing with water
- Extrusion of the paste into pellets
- Drying at 105 °C
- Calcination at 850-950 °C for 2 h







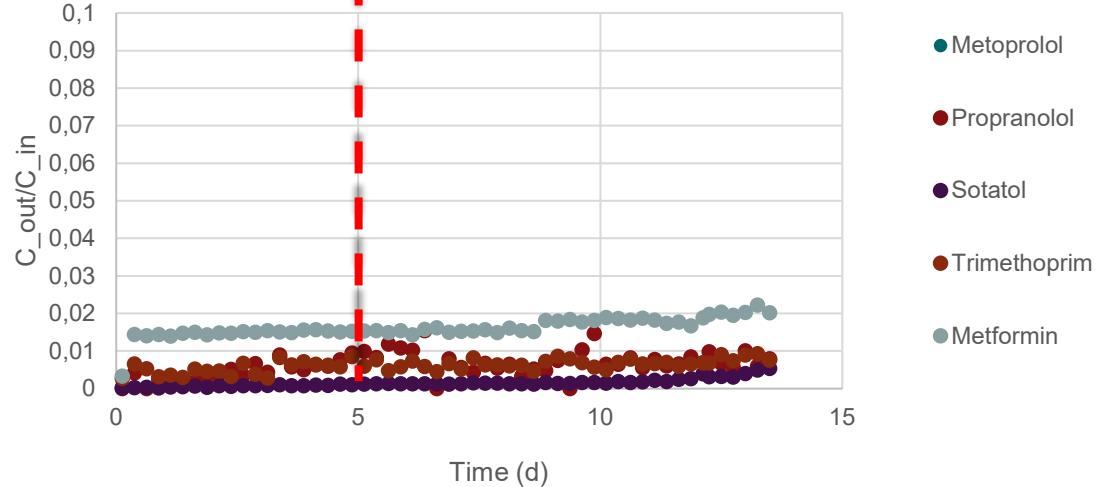
# Adsorption of OMPs by zeolite granules in a column





# Adsorption of OMPs by zeolite granules in a column

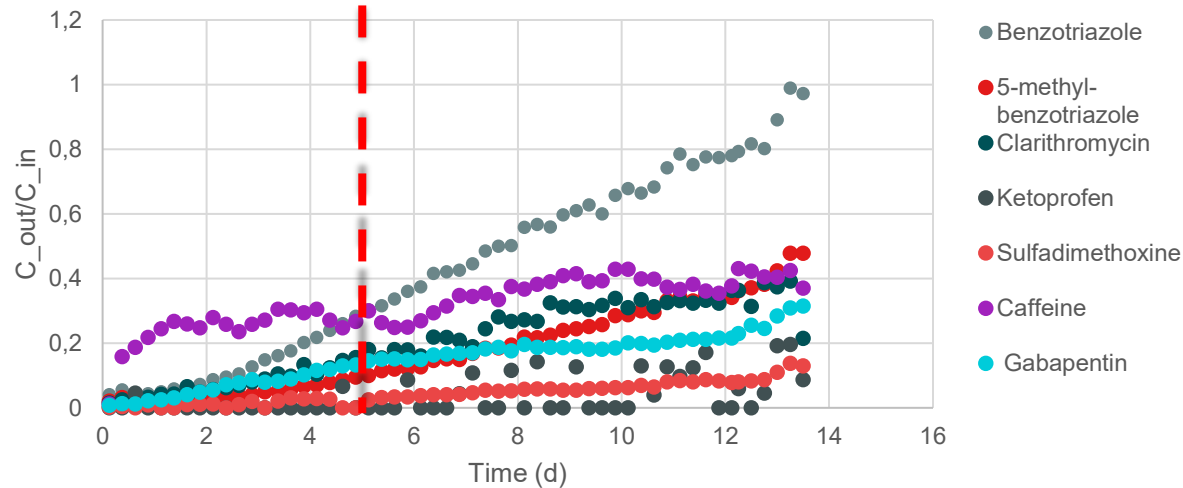
EBCT=6 min, BD=20 cm



High adsorbing OMPs:  
running time 5 days, average removal > 98%

# Adsorption of OMPs by zeolite granules in a column

EBCT=6 min, BD=20 cm

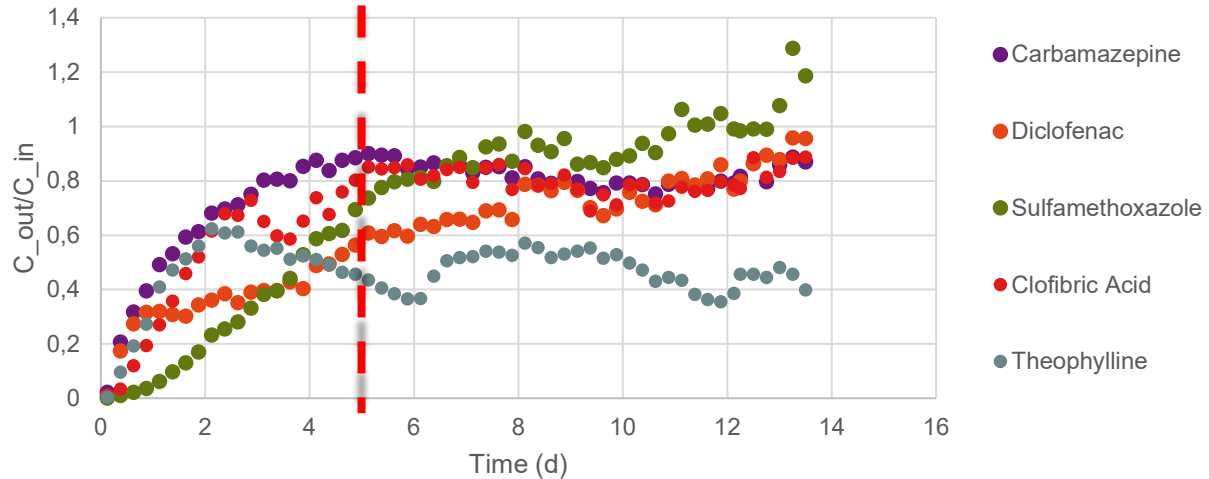


Medium adsorbing OMPs:  
running time 5 days, average removal > 85%

# Adsorption of OMPs by zeolite granules in a column

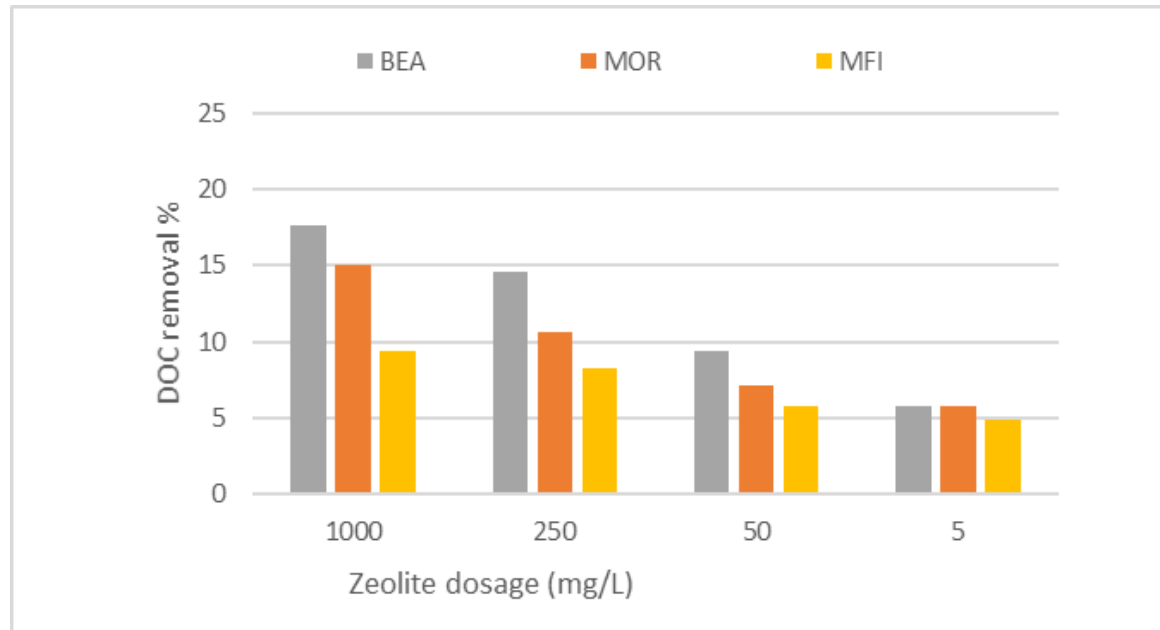


EBCT=6 min, BD=20 cm

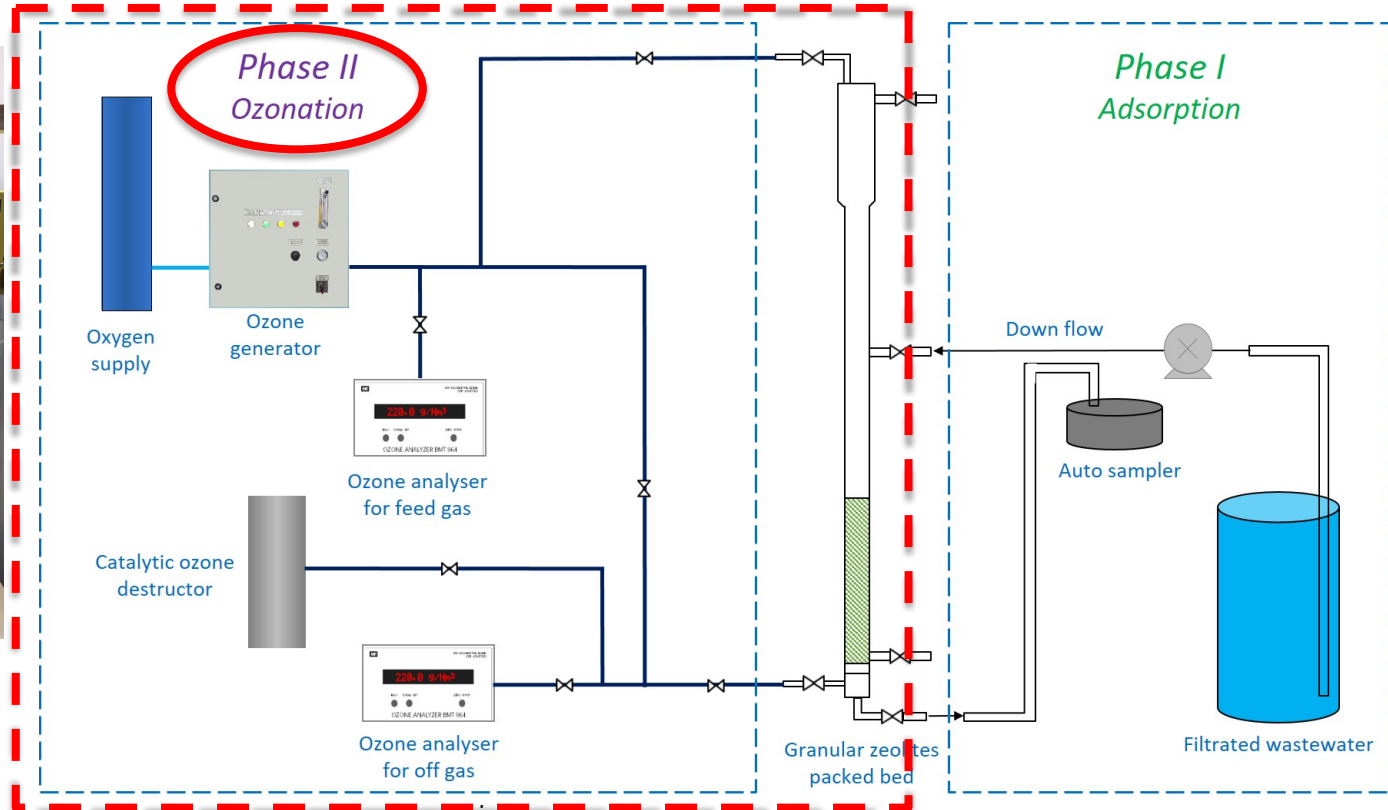


Low adsorbing OMPs:  
running time 5 days, average removal > 55%

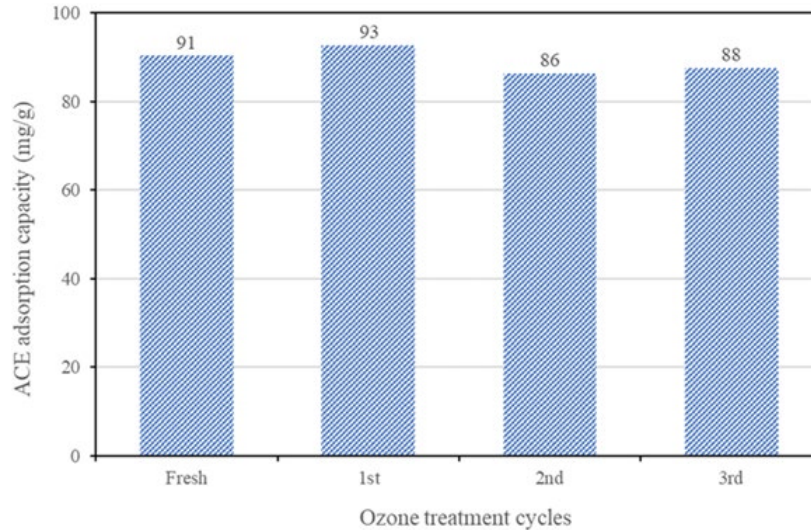
# Adsorption of DOC (background organic matter)



# Regeneration of zeolite granules in a column with ozone gas



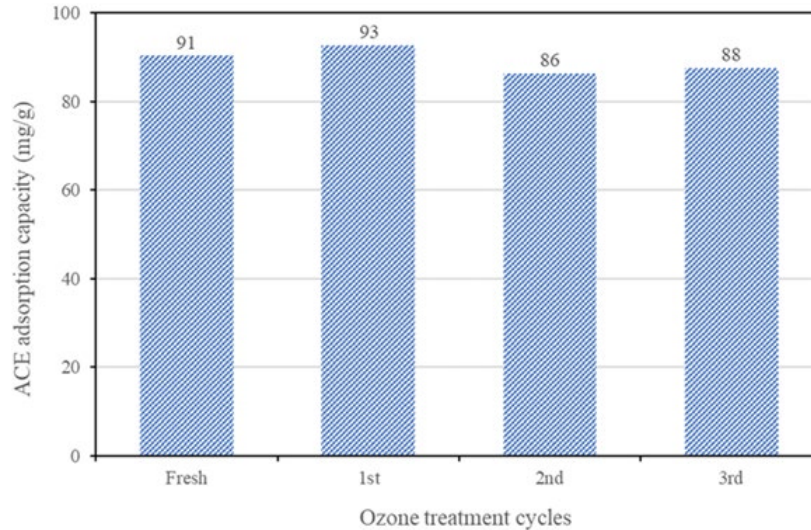
# Regeneration of zeolite granules in a column with ozone gas



- Example: acetaminophen
- Ozone gas: 90 mg/L
- Gas flowrate: 40 m/h (recycled)
- Duration: 3 h



# Regeneration of zeolite granules in a column with ozone gas



- Example: acetaminophen
- Ozone gas: 90 mg/L
- Gas flowrate: 40 m/h (recycled)
- Duration: 3 h

To avoid limitations in ozone gas transfer rate:

- max 20% (w/w) water content
  - draining to 40%
  - drying to 20%



## Lessons learned from lab research

- High removal efficiency ( $> 80\%$ )
- Low influence of DOC
- Effective use of ozone
- No transformation products and **no bromate**
- Short EBCT (5-10 min)
- Compact filters, frequent regeneration on-site
- Cost-effective and sustainable process



IPMV criterion	Unit	PACAS	Ozone + sandfilter	AdOx EBCT 5 min	AdOx EBCT 10 min
CO <sub>2</sub> footprint	g CO <sub>2</sub> /m <sup>3</sup>	122	130	65	123
Costs	€/m <sup>3</sup>	0.06	0.17	0.13-0.17	0.15-0.24
Removal efficiency target compounds I&W	%	70-75	80-85	80-85	80-85
Reduction ecotoxicological risks	%	≥ 50	≥ 50	> 50	> 50

**NO BROMATE**

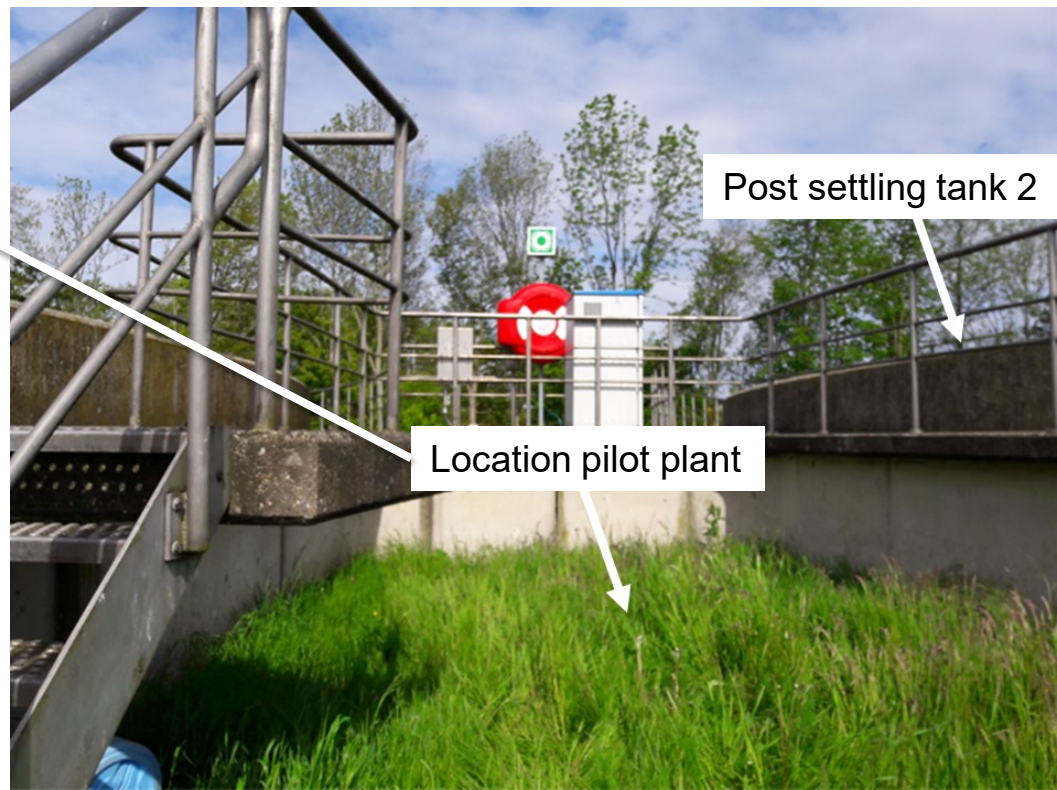
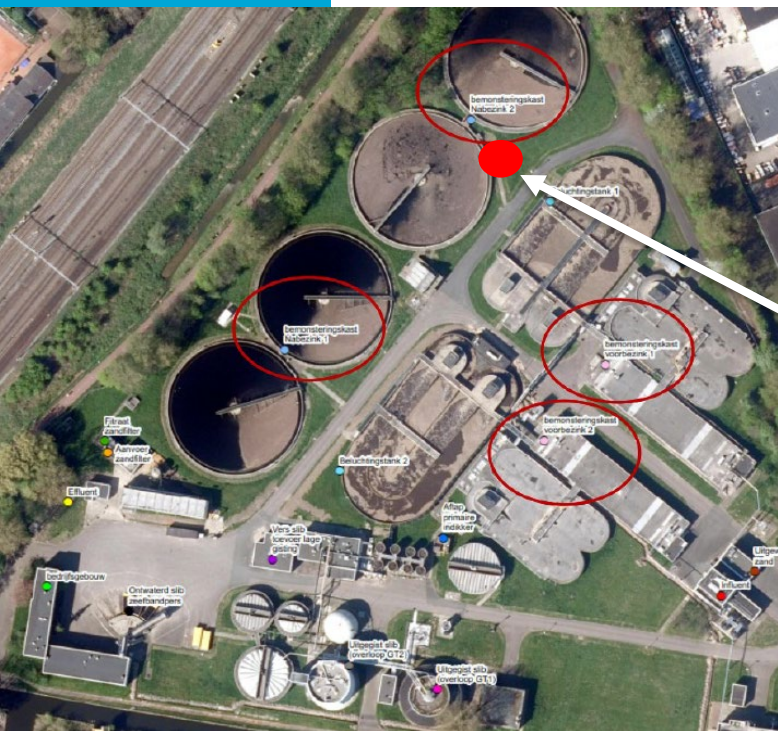


# Proof of practice

- Pilot plant research:
  - Proposal (PvA) submitted
  - Execution in 2022
  - Relative small capacity 0.5 m<sup>3</sup>/h
  - Only one column (no “merry-go-round”)
  - Location WWTP Leiden-Noord (Rijnland)
  - Partners Water Authority Rijnland, Water Authority Delfland, Water Authority De Dommel, Waternet
  - Support from Xylem and Witteveen & Bos



# Location WWTP Leiden-Noord

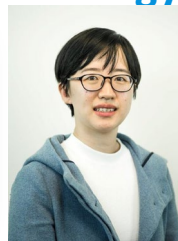




**Thank you for your attention!**

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**Delft University of Technology**



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Rijkswaterstaat  
Ministry of Infrastructure  
and Water Management

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Aquatech Amsterdam**