AquaNES

Ozonation combined with natural filtration processes - water quality gains

BLUE PLANET - Berlin Water Dialogues
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www.aquanes.eu

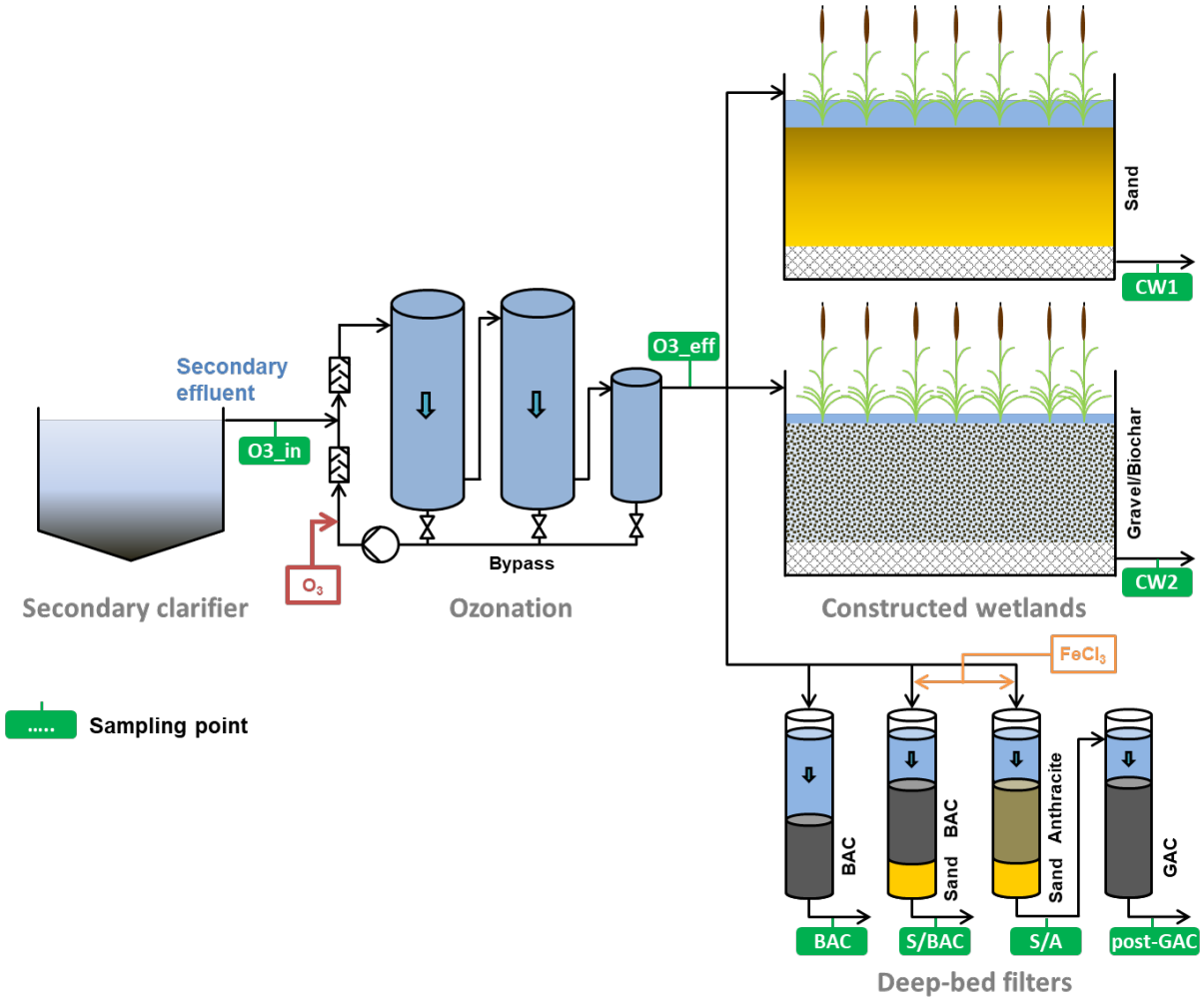
Outline

1. Treatment goals
2. Pilot-plant
3. Results
4. Conclusions
5. Outlook

1. Treatment goals

- **Removal of organic micropollutants**
  - meet 80% reduction for 6 compounds; no defined effluent quality criteria per compound
  - minimization of toxicologically relevant transformation products
- **Disinfection**
  - Thresholds for *E.coli* und Enterococci according to EU-Bathing Water Directive
  - Additional indicators for viruses and spore-forming bacteria
- **Enhanced phosphorus removal**
  - Target threshold: Total P = 0.1 mg/L

2. Pilot plant



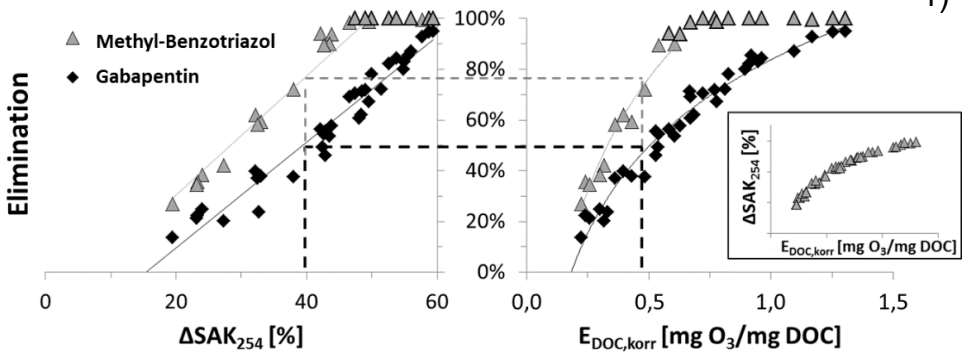
- **Ozonation**
  - Dose: 0,7 mg O_3/mg DOC
  - Control via ΔUVA_{254}
  - HRT ≥ 15 min
- **Constructed wetlands**
  - Vertical flow CW
  - A_F = 11 m²
  - v_F = 200 / 400 / 1000 mm/d
- **Deep-bed filters**
  - A_F = 0,07 m² (d = 0,3 m)
  - v_F = 10 / 5 m/h
  - Coagulant dosing in dual-media filters

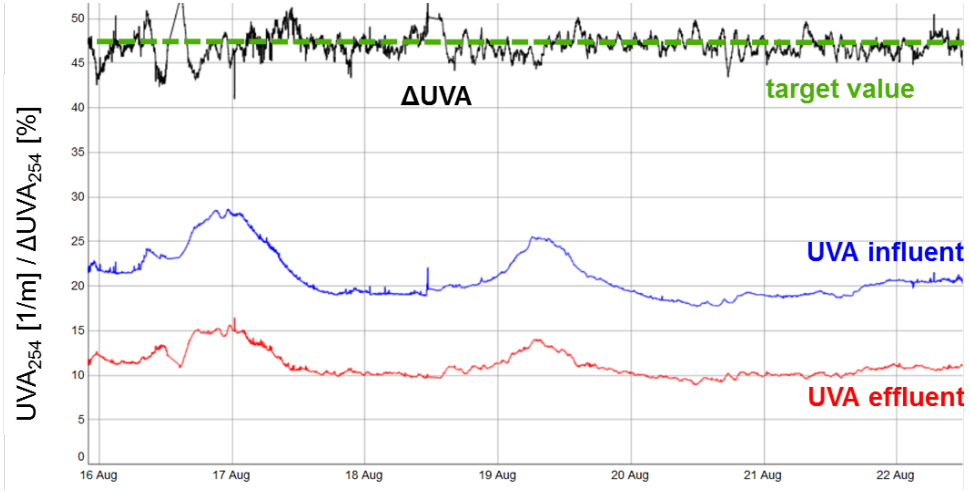
3. Results
ΔUVA_{254} control of ozone dose

- **Background**
  - OMP removal correlates with ozone dose and ΔUVA_{254}
  - ΔUVA_{254} as control parameter for ozone dose / OMP removal

- **Application**
  - Target ozone dose of 0.7 mg O_3/mg DOC correlates with ΔUVA_{254} of 47 % (wastewater specific)
  - Adapted ozone dose keeps ΔUVA_{254} constant despite of changing influent water quality

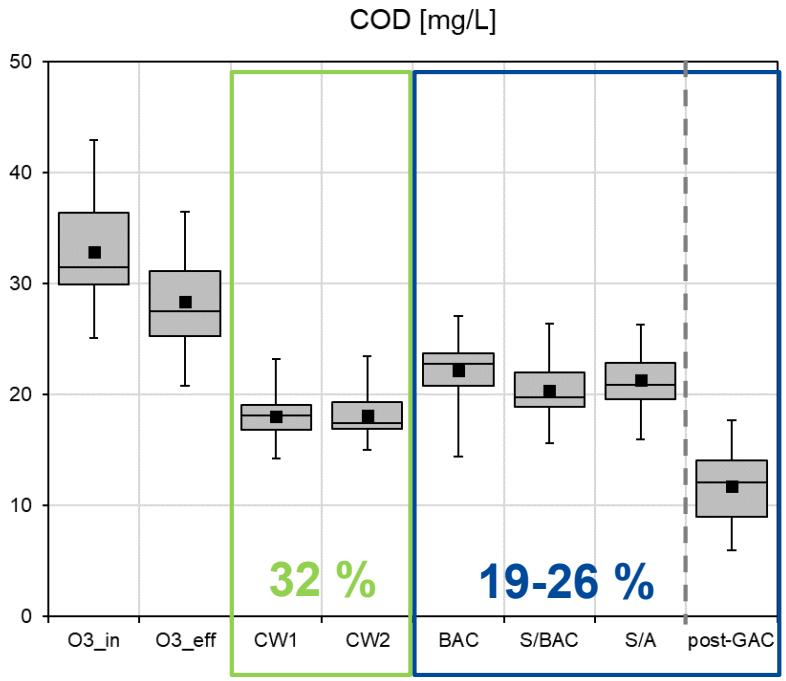
1)

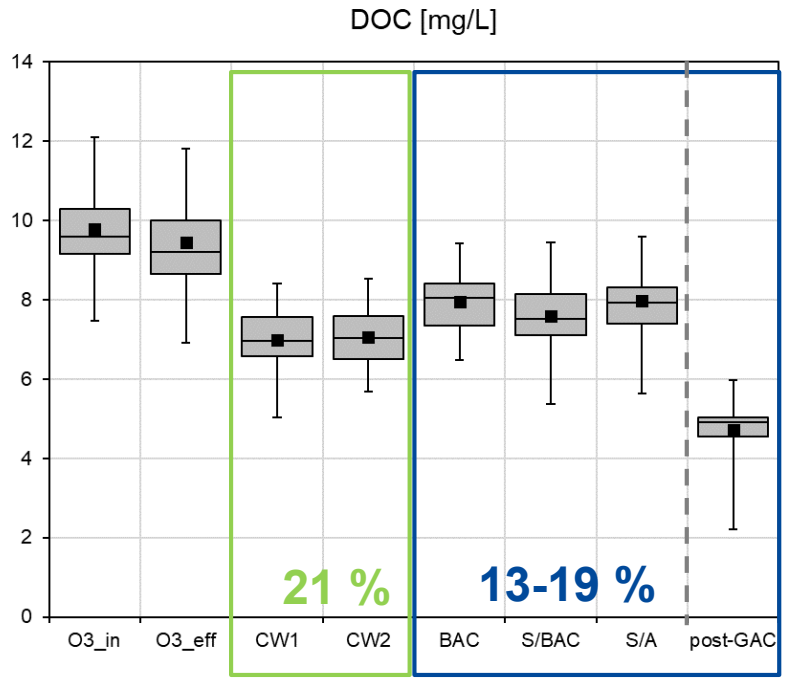




[1] Hilbrandt, I. (2016). Spurenstoffelimination mittels Ozon im Labormaßstab unter Berücksichtigung der Wasserqualität sowie weiterer Einflussfaktoren. Wasserreinhaltung, TU Berlin. Master.

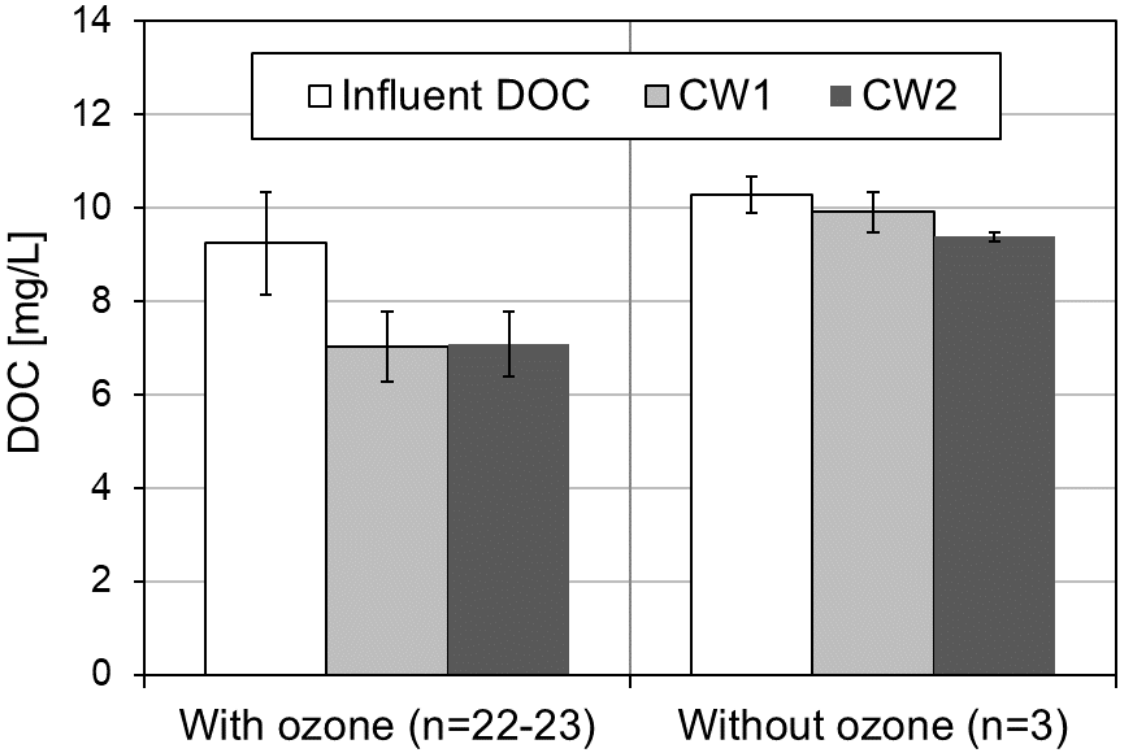
3. Results
Organic bulk parameters





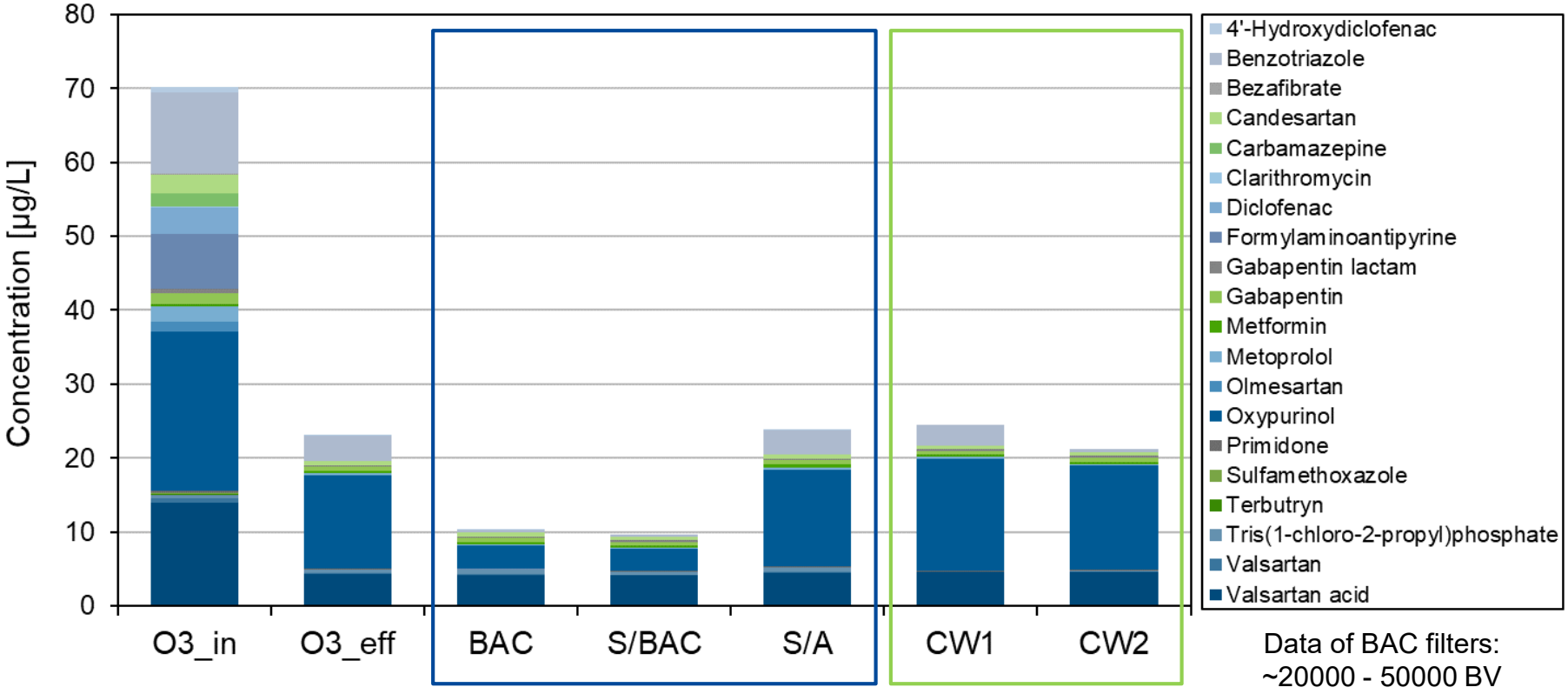
- Constructed wetlands perform better than deep-bed filters → retention time
- S/BAC performs better than S/A filter → Higher bioactivity on BAC than on anthracite?

3. Results
Organic bulk parameters



- Average DOC removal **with** ozone: **21 %**
- Average DOC removal **without** ozone: **4 %**

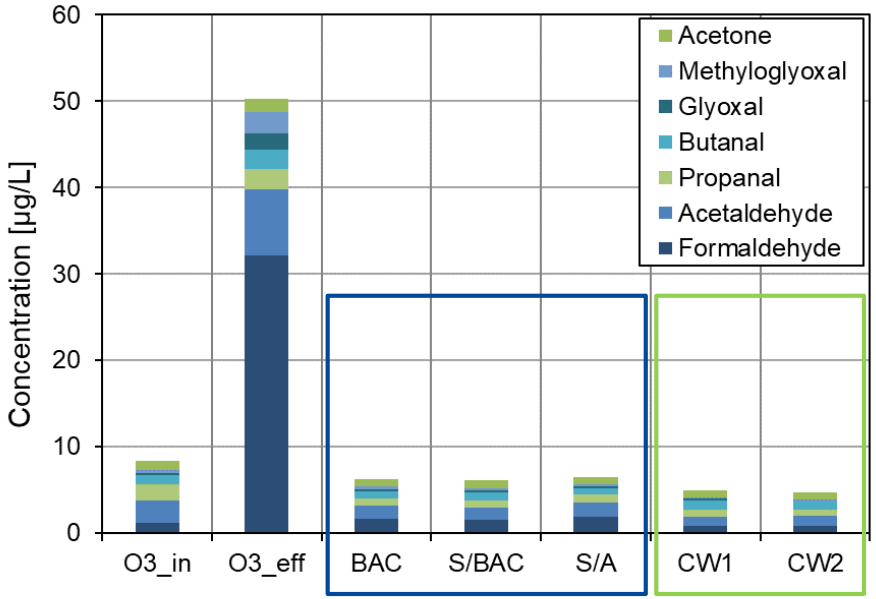
3. Results
Organic micropollutants



- No relevant additional removal of micropollutants in CW and S/A filter
- BAC filters reduce overall OMP concentration by ~ 50 % → sorption and/or biotransformation?

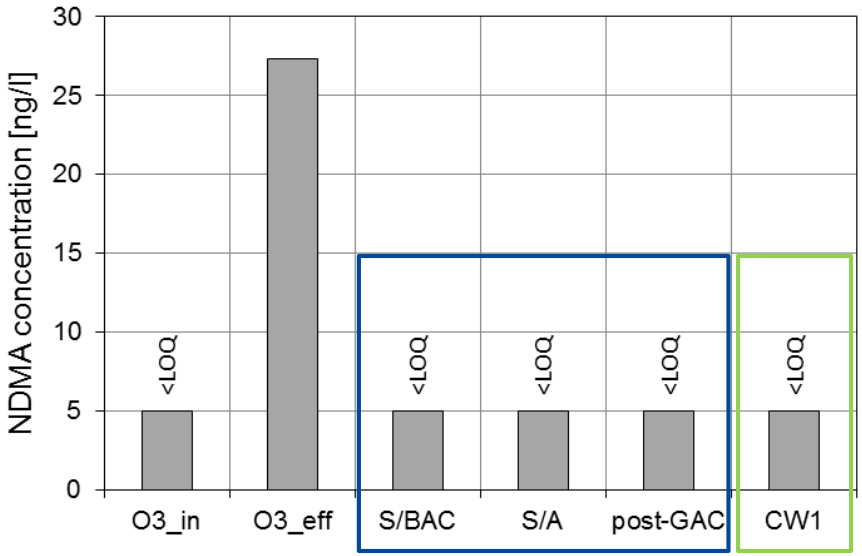
3. Results
Oxidation by-products

- **Aldehydes & ketones[1)] (n=2-3)**



  - Increase of aldehyde and ketone concentrations by oxidation of bulk organic matter
  - Removal in all post-treatment steps below levels of ozonation influent

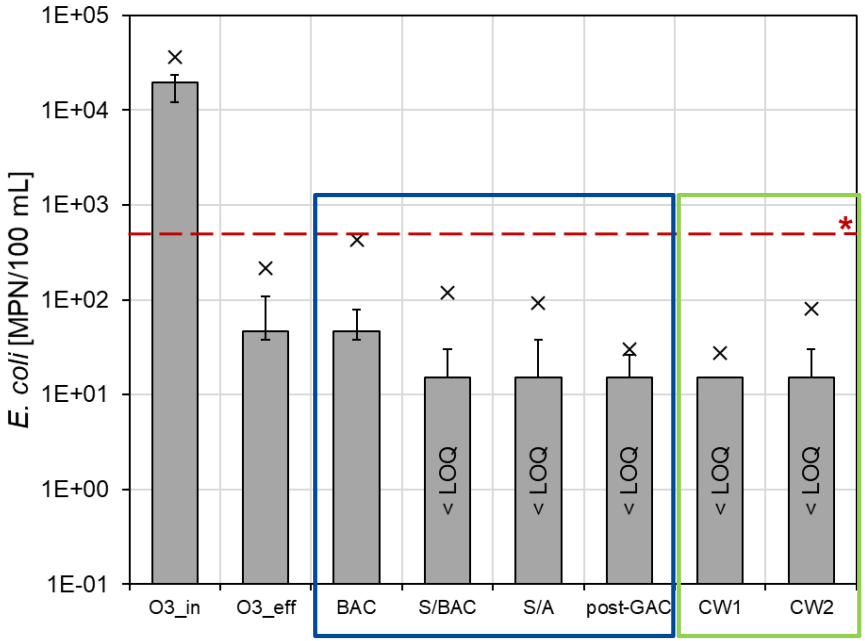
- **N-Nitrosodimethylamine (n=3)**

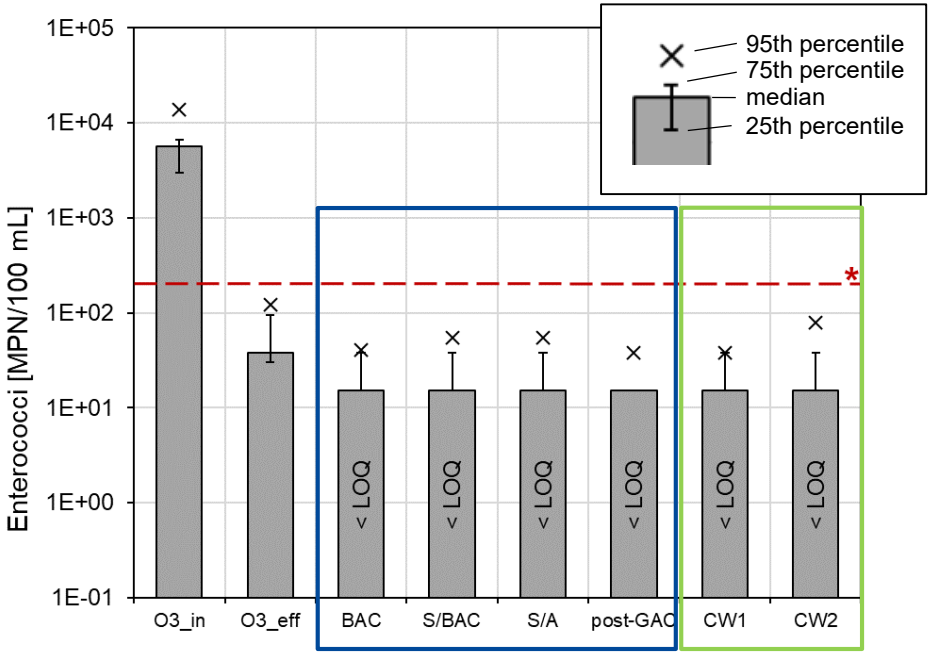


  - Formation of ~ 20-30 ng/L NDMA
  - Removal in all post-treatment steps below level of quantification

[1)] Chemical analysis by Faculty of Chemistry, Adam Mickiewicz University, Poznan.

3. Results
Disinfection: *E. coli* and Enterococci

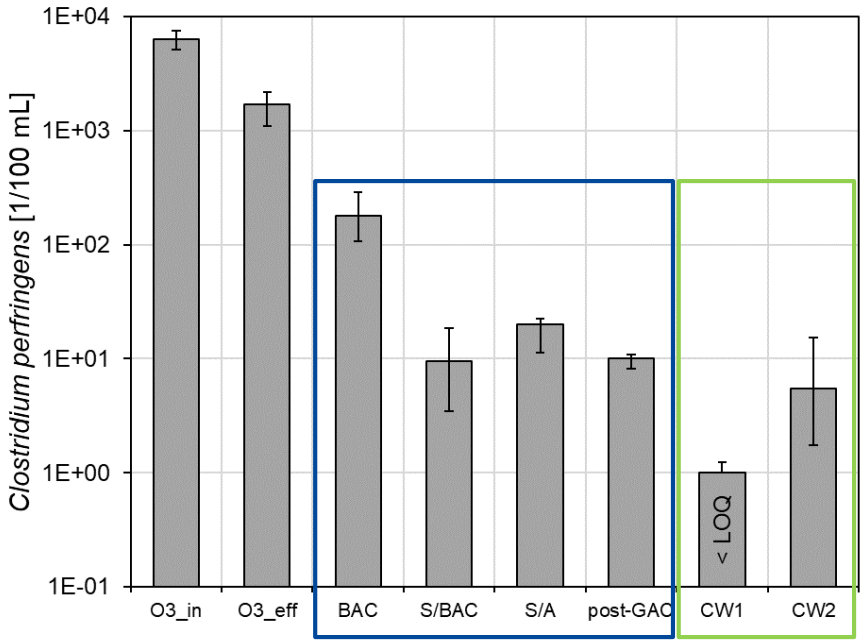


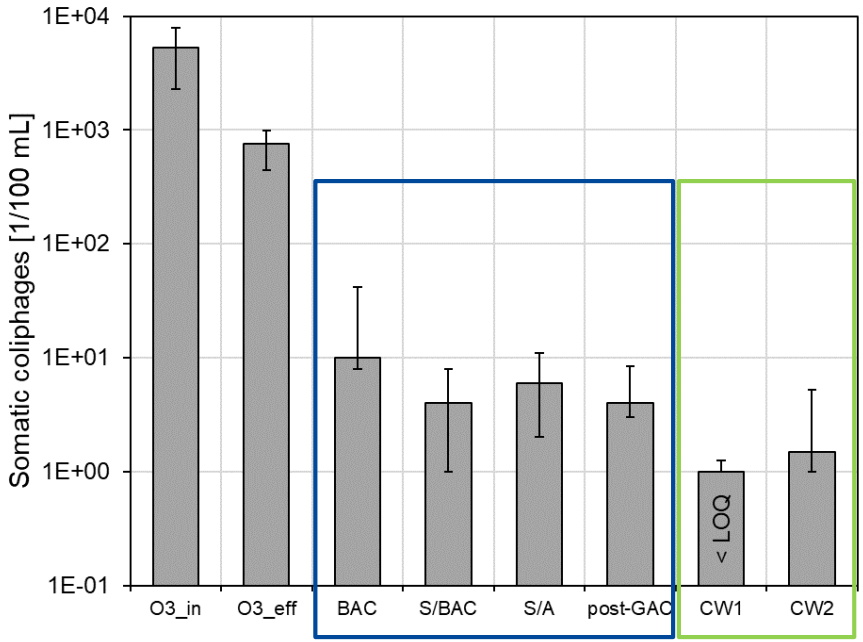


* excellent quality according to EU-BWD

- Efficient removal of *E. coli* und Enterococci with ozone (~ 2 log-units, comparable to UV-radiation in Berlin) + 1 log reduction in post-treatment (except BAC for *E. coli*)
- Compliance with criteria for excellent quality according to EU-Bathing Water Directive

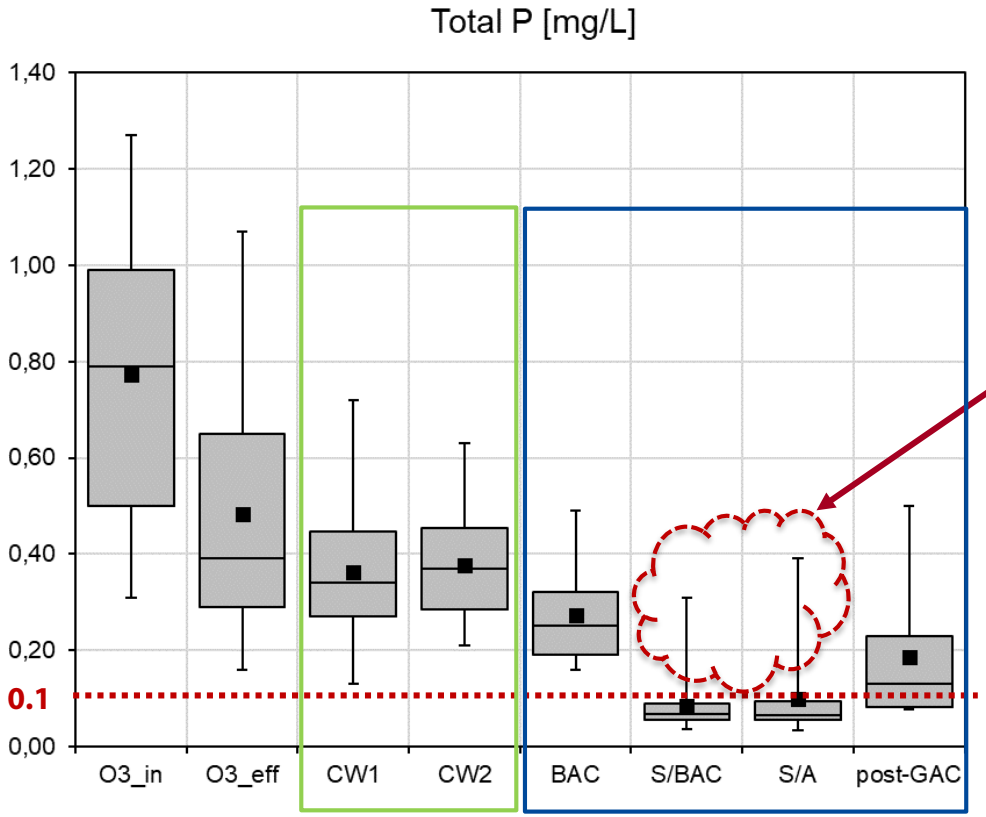
3. Results
Disinfection: *C. perfringens* and coliphages





- Inefficient removal of spore-forming *Clostridium perfringens* with ozone + strong reduction in post-treatment (~ 2 log-units, except BAC)
- Moderate removal of somatic coliphages with ozone (~ 1 log-unit) + strong reduction in post-treatment (~ 2 log-units, except BAC)

3. Results
Phosphorus removal



Phophate peaks in
WWTP effluent
→ coagulant dose was too low

- Stable reduction of Total P below 0.1 mg/L with molar ratio Fe/srP = 4.4

4. Conclusions

- Removal of bulk organic matter was higher…
  - …in constructed wetlands compared to deep-bed filters (retention time)
  - …in BAC filters compared to anthracite (higher bioactivity on BAC?)
- Organic micropollutant removal during ozonation confirmed previous experiences
- Additional organic micropollutant removal during post-treatment was only observed for BAC filters (advantages of granular activated carbon for long-term operation?)
- Oxidation by-products (aldehydes, ketones, NDMA) were removed down to levels of ozonation influent or below in all investigated post-treatment steps

4. Conclusions

- **Disinfection**
  - Compliance with criteria for excellent quality according to EU-Bathing Water Directive
  - *Clostridium perfringens* and somatic coliphages were mainly removed during post-treatment (retention time and grain size seemed to play a role)

- **Phosphorus removal**
  - Additional P-removal can be integrated in post-treatment as a flocculation/filtration step
  - A Total P threshold of 0.1 mg/L could be met with a molar ratio Fe/srP of 4.4

5. Outlook
Full-scale ozonation at WWTP Schönerlinde

Visit the virtual tour through the plant!

- **Link:**
  http://www.aquanes.eu/18-07-18_BWB-Aquanes_Pano-Englisch_01/Start-Pano-Englisch_BWB_by_3D-Agentur-Berlin.html

Thank you for your attention.

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AquaNES

Demonstrating Synergies in Combined Natural and Engineered Processes for Water Treatment Systems

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