CWPharma2
CLEAR WATERS FROM PHARMACEUTICALS

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Ozonation operations and bromate mitigation

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Kalundborg on the map

Kalundborg WWT Plant

- + 60% Industrial waste water
- Traditional 3 step BIODENIPHO
- 50 000 PE with booster
- Full-scale/Full-stream Ozon
- Full-scale/Full-stream MBBR
- Hydrogen Peroxide (H_2O_2)
- 10 MW effluent WW Heat Pump
- Tissø 2 waterworks (surface water)

CWPharma/CWpharma2 participation has made a significant difference

- An ozone facility originally designed for COD removal – now also optimized and trimmed for API removal
- Total yearly operating cost reduced to about 1/5 of pre CWPharma estimates
- Knowledge by interregional collaboration
- Boost in know-how to all parts of our organization
- New possibilities for collaboration with our industrial partners in the Kalundborg Industrial Symbiosis
- Permanent WWT in Kalundborg with ozone to remove API and micro pollutants – without formal legal demands – since March 22nd 2019
- Great difference to the environment

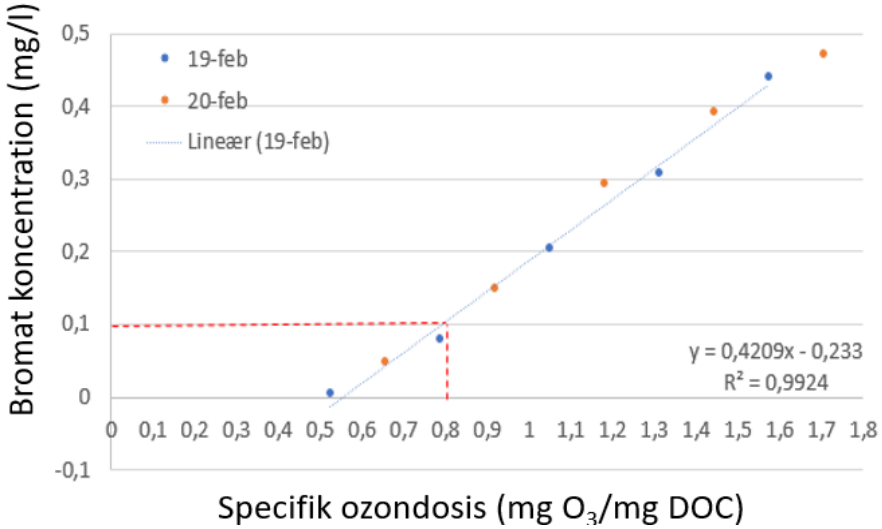
CWPharma results documented

- Result from CWPharma documented in the report: ”Evaluation and experiences of full-scale ozonation followed by MBBR post-treatment at Kalundborg wastewater treatment plant” (CWPharma website)

- For example:
- Operation and optimization of a full-scale ozonation system
- Dose-Response test for API and Bromate
- Bromide tracking for the Kalundborg WWT Plant
- Transformation products
- Ecotox test and environmental risk assessment

From CWPharma to CWPharma2

Bromate formation:



From CWPharma to CWPharma2

Relining of an older sewage line will reduce bromide in influent with about 50%:

From CWPharma to CWPharma2

Kalundborg is one of the very few WWTP with the possibility to operate both with a combined full-scale CAS + ozonation + full-scale MBBR. Therefore, in CWPharma2 we wanted to investigate how to:

- Use a full-scale MBBR facility as a post-ozonation treatment
- Strip of “left-over” oxygen
- Achieve possible further API reduction after the CAS and ozone treatment
- Possibly reduce Bromate formed as a transformation product from Bromide, which in Kalundborg comes from intrusion of seawater (50 % from an old sewage transmission line) and 50% from the industry – inspired by results from Lunds University, Sweden
- Further optimize the ozonation full-stream process

From CWPharma to CWPharma2

Inspired by results from Lund University, Sweden – (Lauren Dell et all.): “Yield of Bromate from Ozonated Wastewater and the Potential for Biological Reduction of Bromate in Wastewater in Sweden”

- Bromate acts as an electron acceptor in bacterial processes
- A number of bacterial species have been shown to be capable of bromate reduction
- Co-metabolic reduction pathways versus bromate-specific mechanisms have both been hypothesized

From CWPharma to CWPharma2

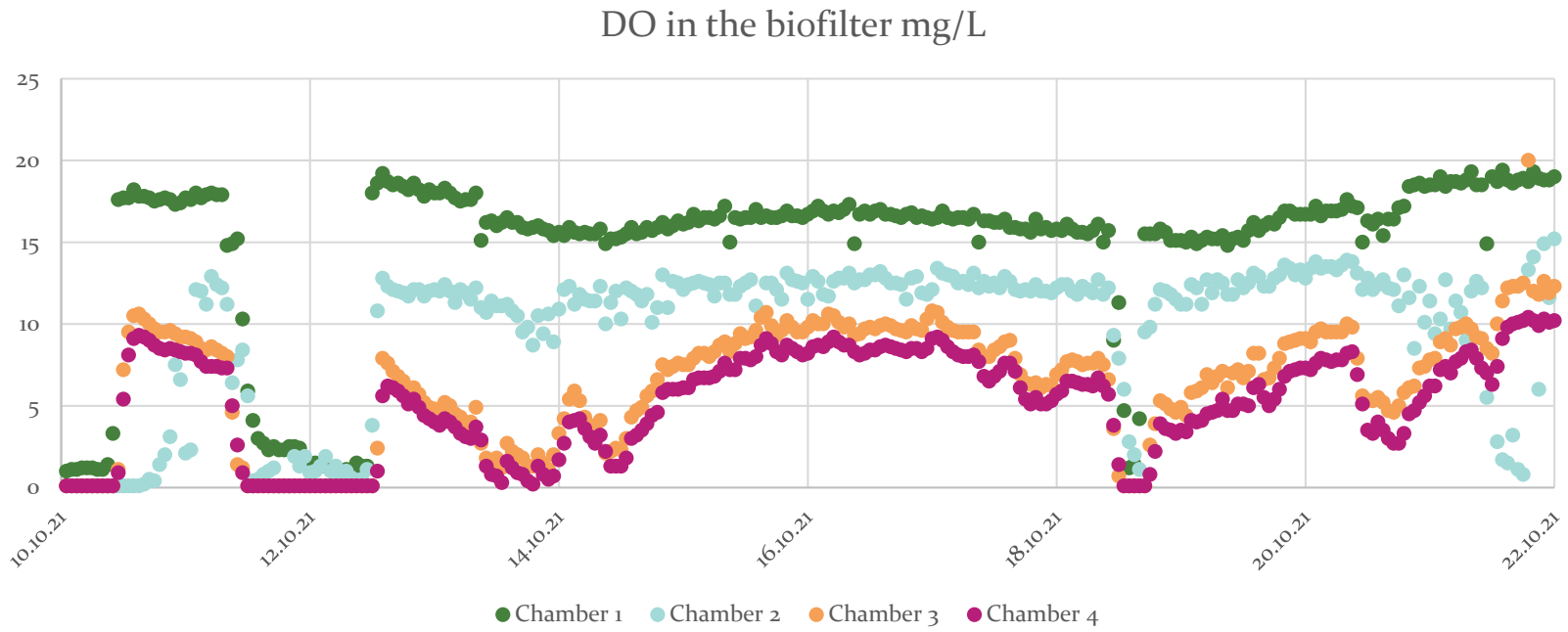
Example of laboratory experiments - Lund University, Sweden – (Lauren Dell)

From CWPharma to CWPharma2

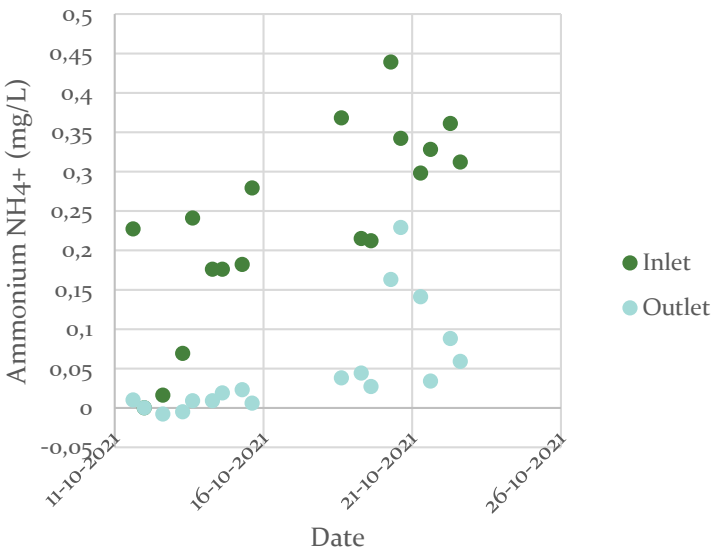
Example of results -Laboratory experiments - Lund University, Sweden – (Lauren Dell)

- Wastewater and carriers from Sjölunda WWTW post-denitrification tank
- BrO3-reduction began immediately
- 100% removal of bromate within 90 minutes
- Linear rate of removal
- Increase in concentration of bromide

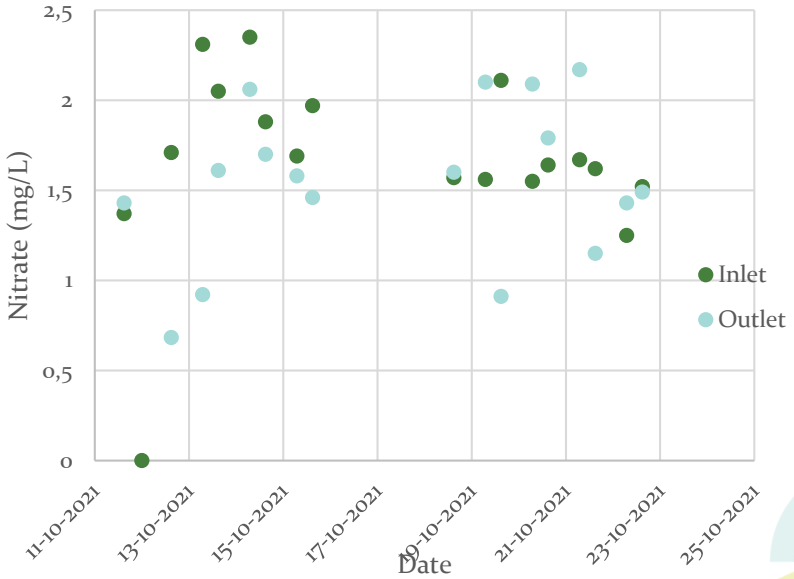
How about full-scale in Kalundborg


DO in the biofilter mg/L
25
20
15
10
5
0
10.10.21
12.10.21
14.10.21
16.10.21
18.10.21
20.10.21
22.10.21
Chamber 1
Chamber 2
Chamber 3
Chamber 4

Comparison of inlet and effluent NH_4 concentrations



Comparison of inlet and effluent NO_3 concentrations



Operation Experience of full-scale full-stream MBBR

- CAS treated and ozonated effluent = hard time to get an MBBR running
- Limits to retention-times in actual operations of WWTP/MBBR

- Bacteria are sensible species
- Stable delivery or substantial storage capacity of carbon source
- Carbon source prices matters = up to factor 10 in difference
- Certain carbon source prices = prohibitive to the use of MBBR

- The final (successful) strategy:
- Stripping of excess oxygen in chamber 1
- Carbon-source dosing exclusively in chamber 2
- Chamber 3 + 4: as close to zero aeration and circulation as possible

Results from the real life in Kalundborg

- Stripping of “left-over” oxygen - YES
- Continued optimization in all aspects of the use of the ozonation plant and collaboration with our partners in CWPharma2 - YES
- Substantial experience on the operation an MBBR plant on post-ozonated effluent – YES

- Great problems in forming stable an efficient bacteria film on the carriers in the MBBR plant – therefore still outstanding to resolve:
- Possible reduction of Bromate by full-scale full-stream MBBR
- Possible further API reduction after the CAS and Ozone treatment by MBBR

- Maybe in the future: looking into other methods to remove Bromate from post-ozonated effluent

Super Thanks to:

CWPharma 2 project partners:

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Feed-back and questions are welcome

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