

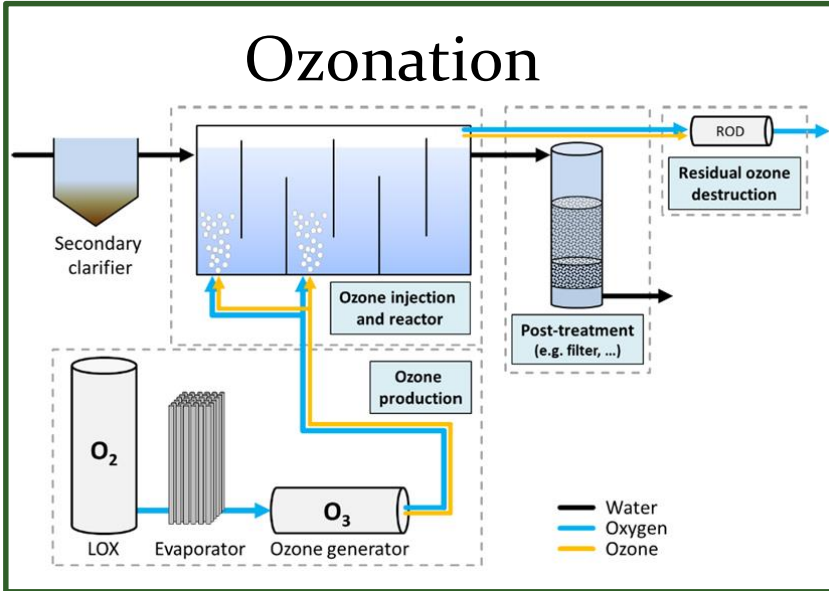


Fitness check of WWTPs for API removal in the BSR

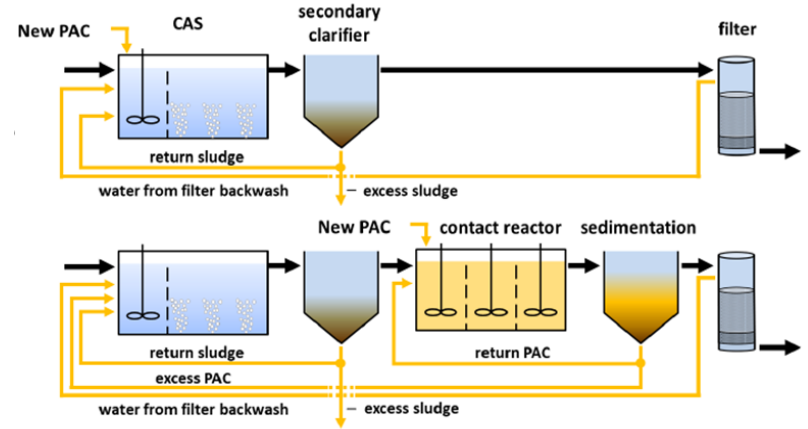
Michael Stapf, Veronika Zhiteneva, Ulf Mieke
Berlin Centre of Competence for Water

Mature API elimination technologies

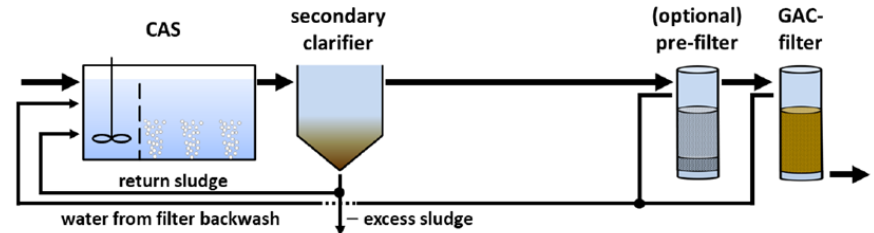
Ozonation



Powdered activated carbon (PAC)



Granular activated carbon (GAC)



Choosing the right technology

Each technology has its pros and cons:

Category	Ozone	GAC	PAC	MBBR
API removal	++	++	++	o
Technology maturity for API elimination	++	++	++	-
Process complexity	-	++	o	+
Reaction products from the water matrix	-	++	++	++
Transformation products or metabolites	-	++	++	-
Costs [#]	+	+	+	o
Operational energy required	-	+	o	+
Carbon footprint	o	o	-	+
Space requirement	++	+	-	-
Subsequent sludge application in agriculture	++	++	-	++

Precursors in wastewater?

Energy prices?

Exchange frequency?

Sludge disposal?

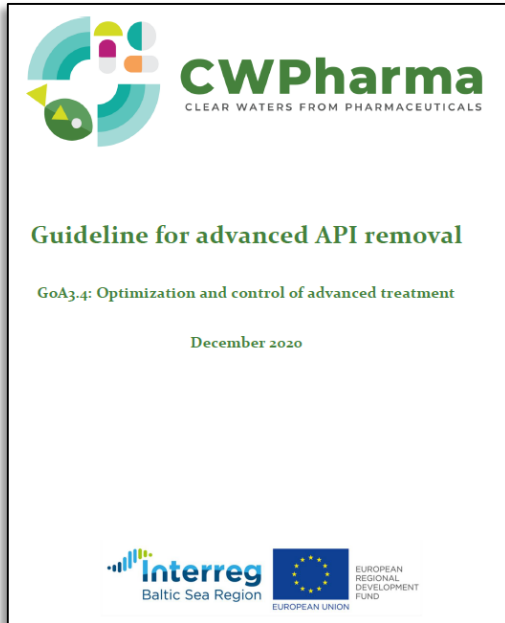
Carbon footprint?

Specific APIs to be removed?

API / micropollutant	Activated carbon	Ozonation
Amisulpride Carbamazepine Citalopram Clarithromycin Diclofenac Hydrochlorothiazide Metoprolol Tramadol Venlafaxine	good – very good (> 70%)	
Benzotriazole Irbesartan Oxipurinol*	good – very good (> 70%)	moderate – average (≈ 30 – 70 %)
Candesartan Formylaminoantipyrine* Olmesartan Sulfamethoxazole	moderate – average (≈ 30 – 70 %)	good – very good (> 70%)
Valsartan Valsartan acid*	moderate – average (≈ 30 – 70 %)	
Gabapentin	none – low (< 30 %)	moderate – average (≈ 30 – 70 %)

*metabolite/transformation product

Let's conduct a WWTP fitness check



- ✓ Check need for / target of API elimination
- ✓ Check data availability
- ✓ Identify potential barriers (e.g. precursors, share of industrial wastewater, sludge disposal)
- ✓ Check for synergies with other goals

Fitness-check in CWPharma 2

- **Individual fitness-check reports** for each participating WWTP with recommendations for further investigation.
- **Summary report** with anonymous results, clustered at regional/country level.

KOMPETENZZENTRUM
Wasser Berlin



**LATVIJAS
HIDROEKOLOĢIJAS
INSTITŪTS**



ESTONIAN
WATER-
WORKS
ASSOCIATION

SINCE
1995



HSY



AARHUS UNIVERSITY

Data basis for evaluation

Questionnaire

Wastewater treatment plant (WWTP) processes

Please check boxes for all processes used. You can also use 'Other' to provide additional information or clarification.

1. WWTP for fees
2. Curri (PE) an
3. Estin wates (please flow ha
4. What concen - carbon - nitrog - phosph (Please depend
5. What at your (AD = MBR = MBRR =
6. Whe end up

Advanced wastewater treatment for pharmaceutical (API) removal

Please check boxes. You can also use 'Other' to provide additional information or clarification.

7. Are you interested in implementing any
 Further COD reduction Further N reduction Further P reduction

8. Have you n concentration
9. In the even what end goal implementa treatment for

Water quality parameters

Please provide average and/or range of concentrations for secondary effluent water quality parameters. If certain parameters are not measured in the secondary effluent, but in the WWTP effluent, please state these instead.

	Unit	Not measured	Secondary effluent	WWTP effluent	Comment
11. Total chemical oxygen demand (COD _t)	mg/L	<input type="checkbox"/>			
12. Dissolved chemical oxygen demand (COD _{de})	mg/L	<input type="checkbox"/>			
13. Dissolved organic carbon (DOC)	mg/L	<input type="checkbox"/>			
14. Total suspended solids (TSS)	mg/L	<input type="checkbox"/>			
15. Nitrite (NO ₂)	mg-N/L	<input type="checkbox"/>			
16. Bromide (Br ⁻)	mg/L	<input type="checkbox"/>			
17. Water temperature	°C	<input type="checkbox"/>			
18. pH	-	<input type="checkbox"/>			
19. Would you be interested in sending us a water sample for analysis of certain water quality parameters as well as APIs? (No costs, results will only be used in anonymous form)			<input type="checkbox"/> Yes <input type="checkbox"/> No		

Please send the finalized questionnaire as word file or scan to: XXX@YYY.ZZZ

19 questions,
translated for DE, LT, LV, PL

Single sampling event



500 ml sample
Insulated box
Ice packs

Parameters:

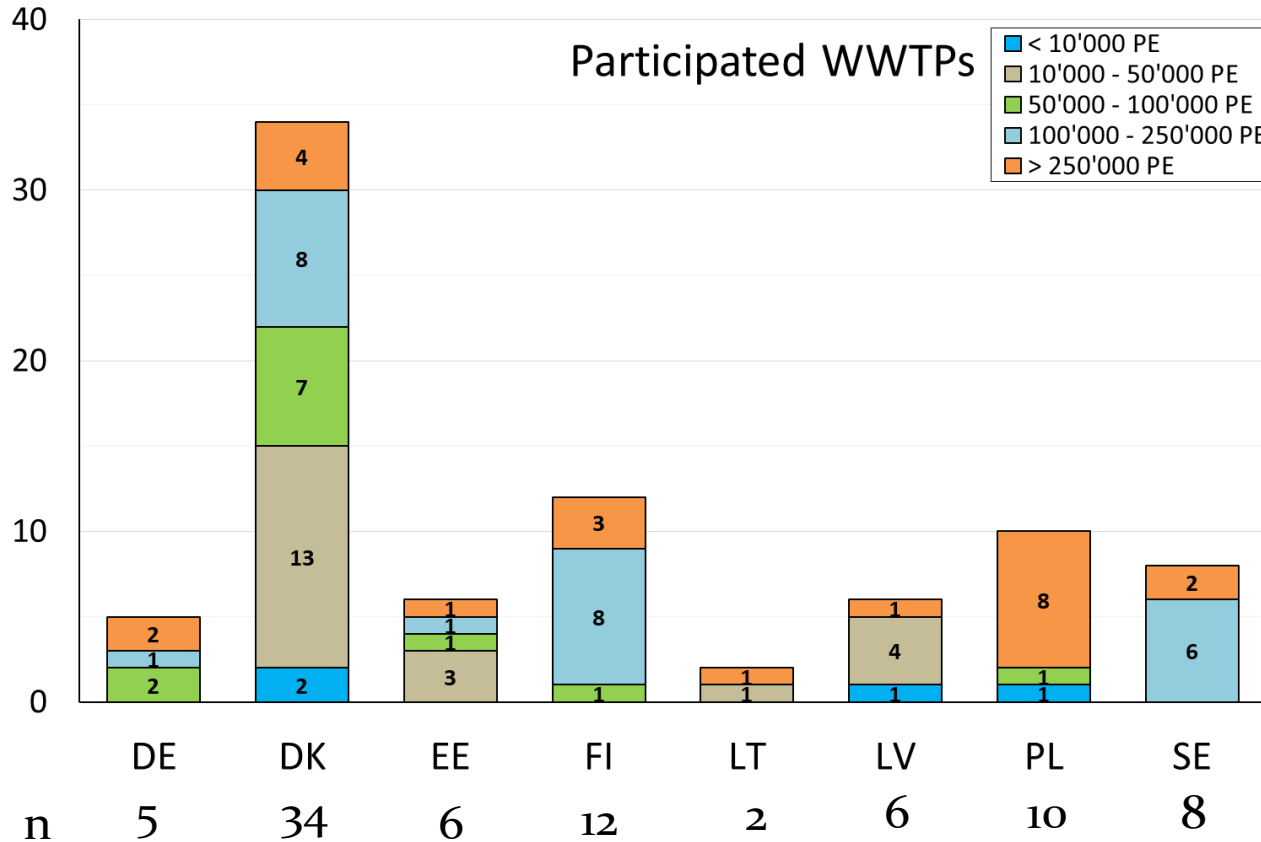
KWB: Nitrite, pH, conductivity, COD, UVA₂₅₄

Aarhus University: APIs

External lab: Bromide, DOC

➔ Not representative, but first impression
of selected water quality parameters

WWTP participation at fitness-check



Industrial wastewater:

< 10% IWW ≈ 50 %

10 – 30 % IWW ≈ 30 %

> 30 % IWW ≈ 20 %

✓ 83 different WWTPs,
2 w/o sampling

Individual WWTP fitness-check



Fitness check for API elimination for WWTPXXX (CC)

CWPharma 2 WWTP code: CC_nn

November 2021

Prepared by:

Berlin Centre of Competence for Water (KWB)



Table of contents:

1) Current status of WWTP

- Treatment process
- Water quality parameters
- API concentrations

2) Evaluation

- Risk evaluation
- Data availability
- Expected PAC/ozone dosages
- Barriers for API elimination technologies
- Interaction with other treatment goals (synergies)
- (Optional) use of existing infrastructure

Individual WWTP fitness-check



Fitness check for API elimination for WWTPXXX (CC)

CWPharma 2 WWTP code: CC_nn

November 2021

Prepared by:

Berlin Centre of Competence for Water (KWB)



Table of contents:

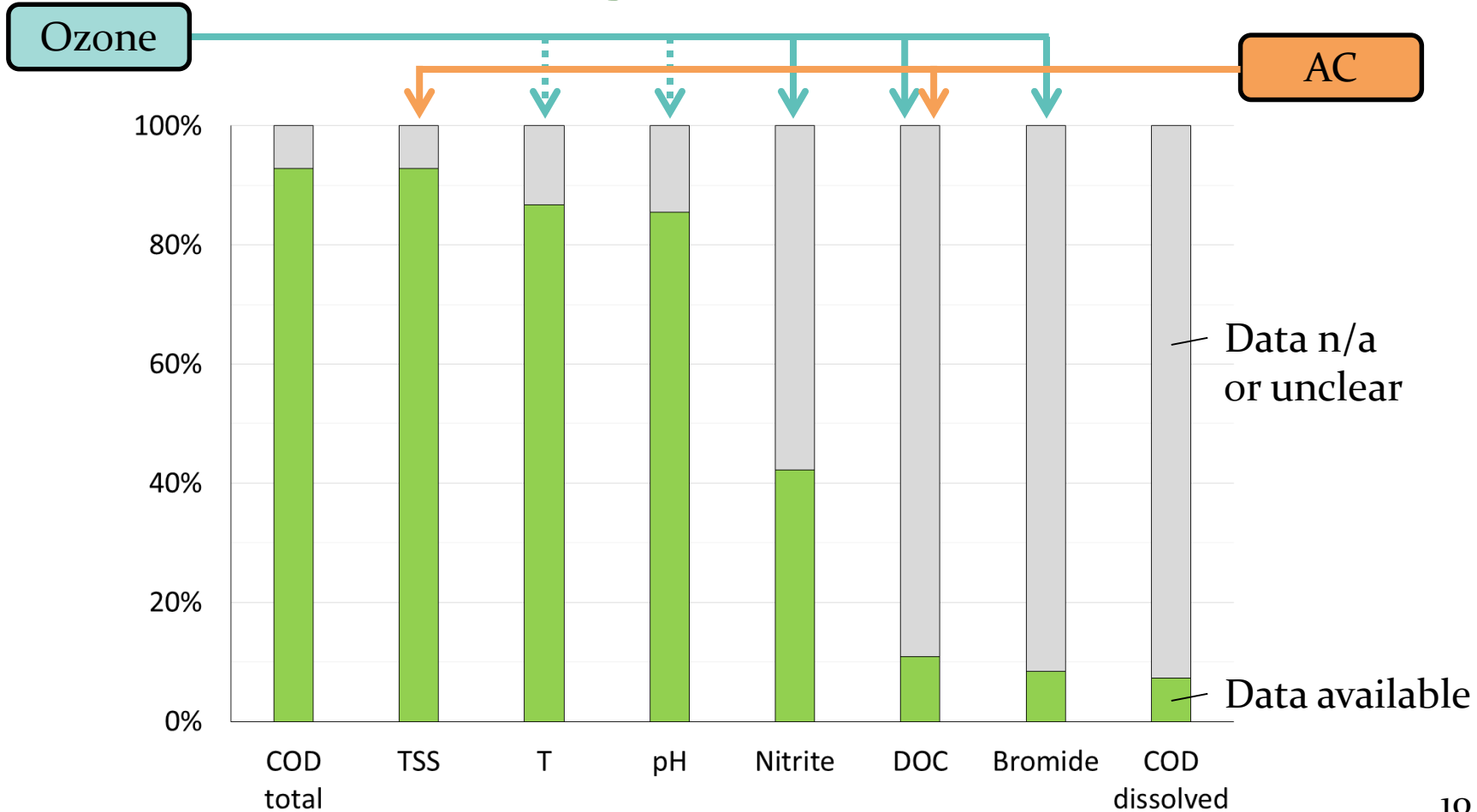
1) Current status of WWTP

- Treatment process
- **Water quality parameters**
- API concentrations

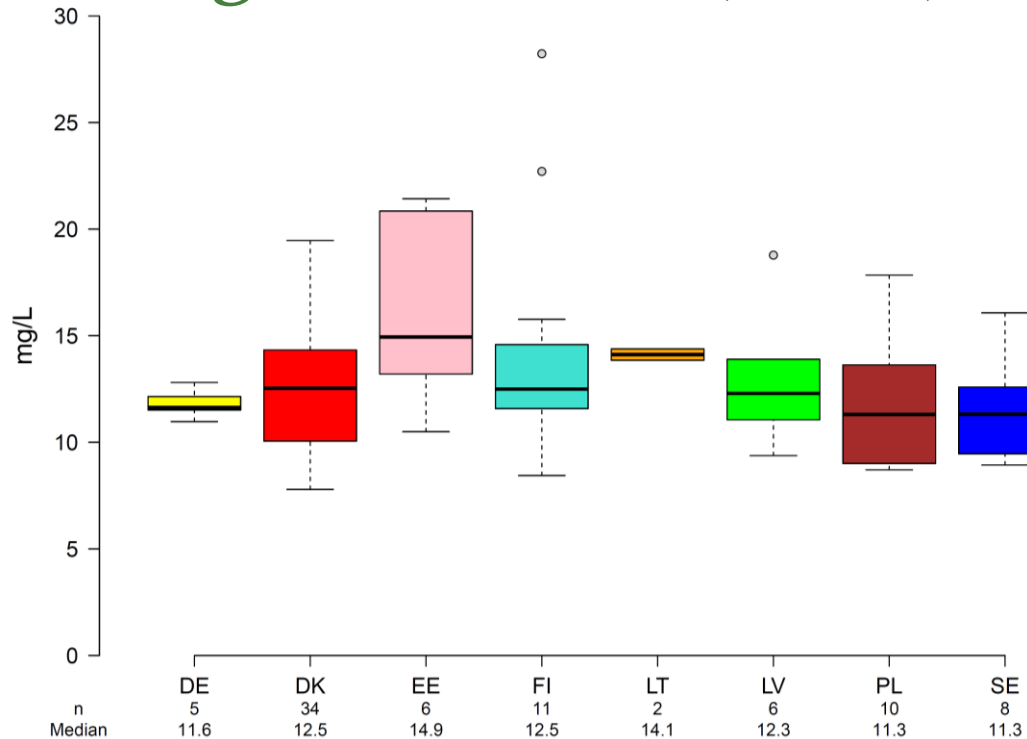
2) Evaluation

- Risk evaluation
- **Data availability**
- Expected PAC/ozone dosages
- Barriers for API elimination technologies
- Interaction with other treatment goals (synergies)
- (Optional) use of existing infrastructure

Overall data availability

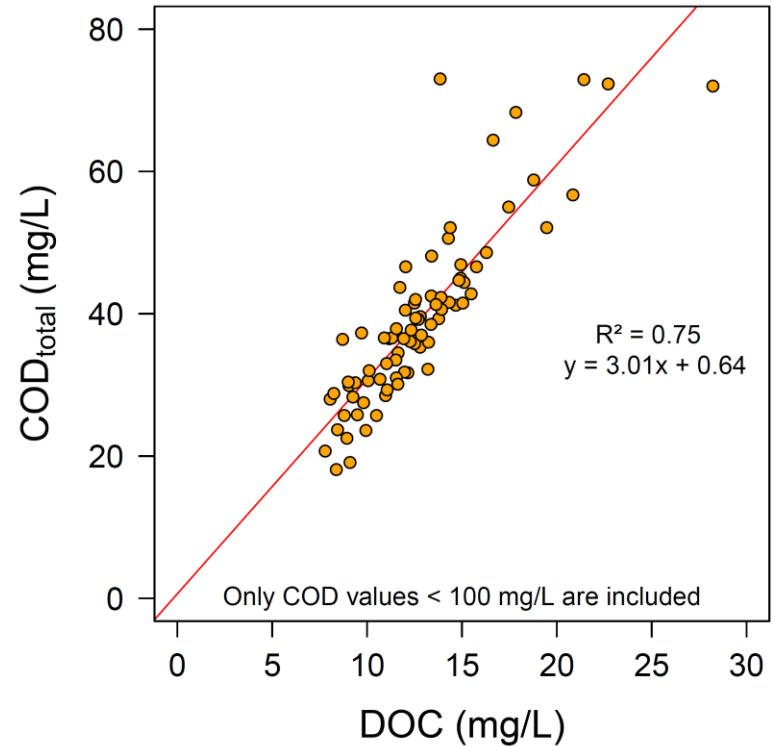
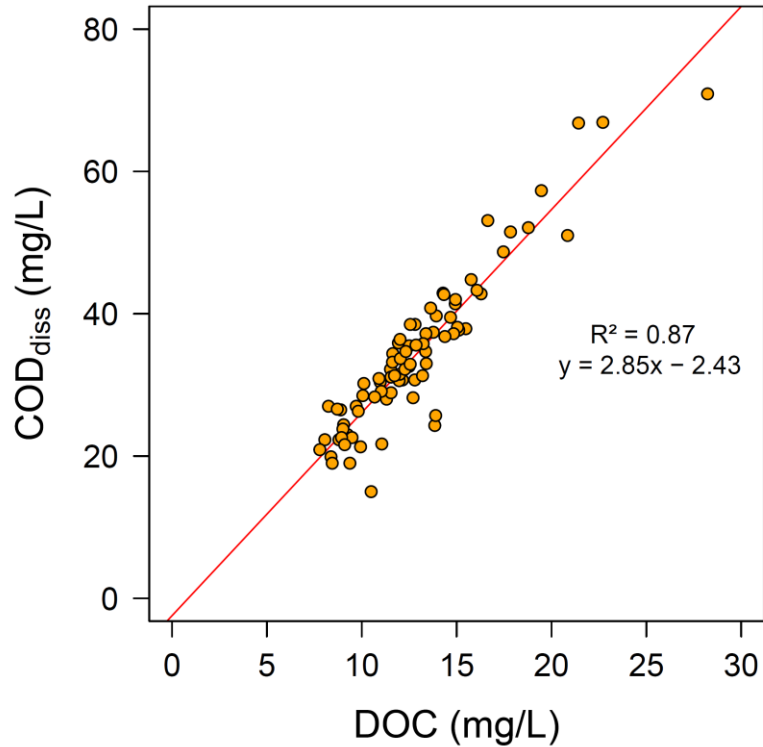


Dissolved organic carbon (DOC)



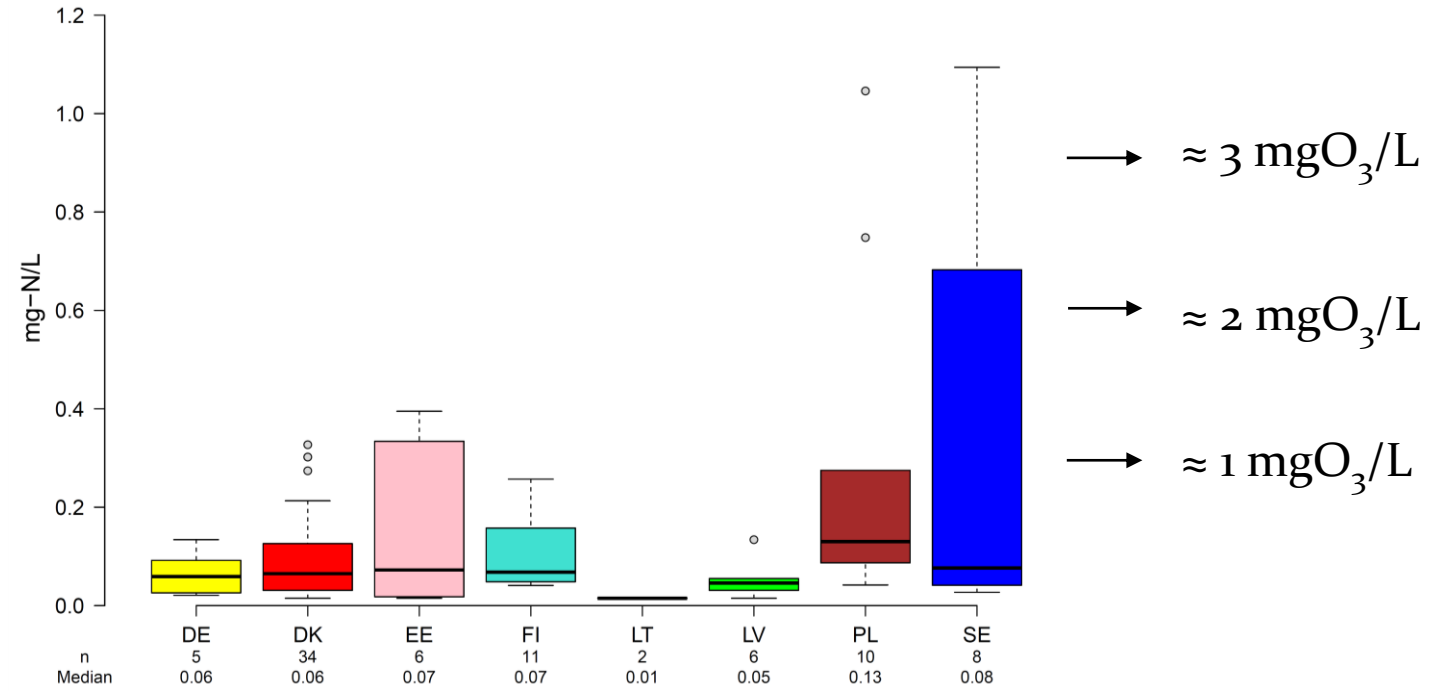
- DOC levels are similar in the BSR, but with strong variations within single countries
- Most WWTPs with existing API elimination technologies in DE / CH have lower DOC

Use of COD instead of DOC?



COD might be used as a surrogate of DOC, which is not measured frequently.

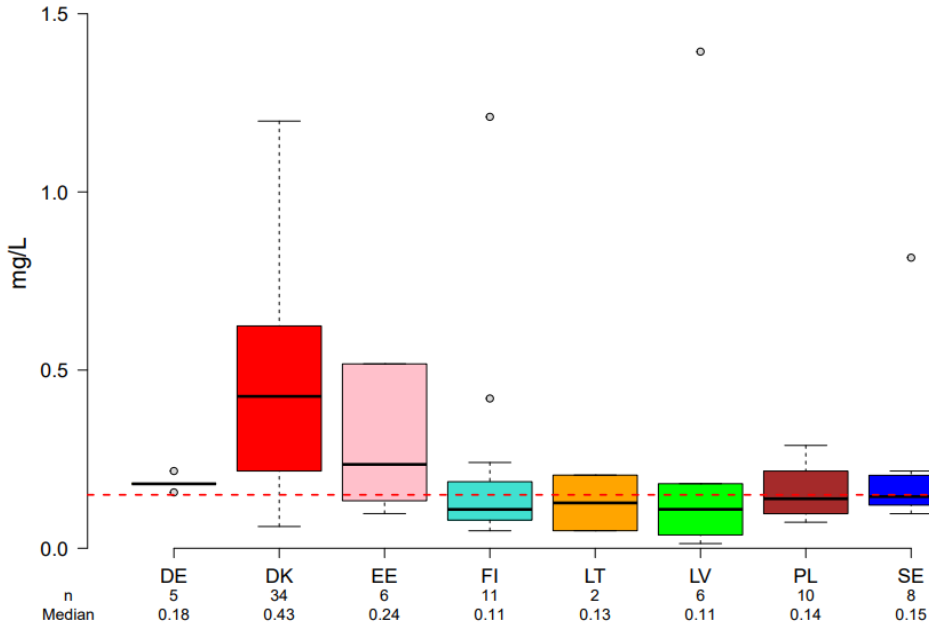
Nitrite (not to be confused with nitrate)



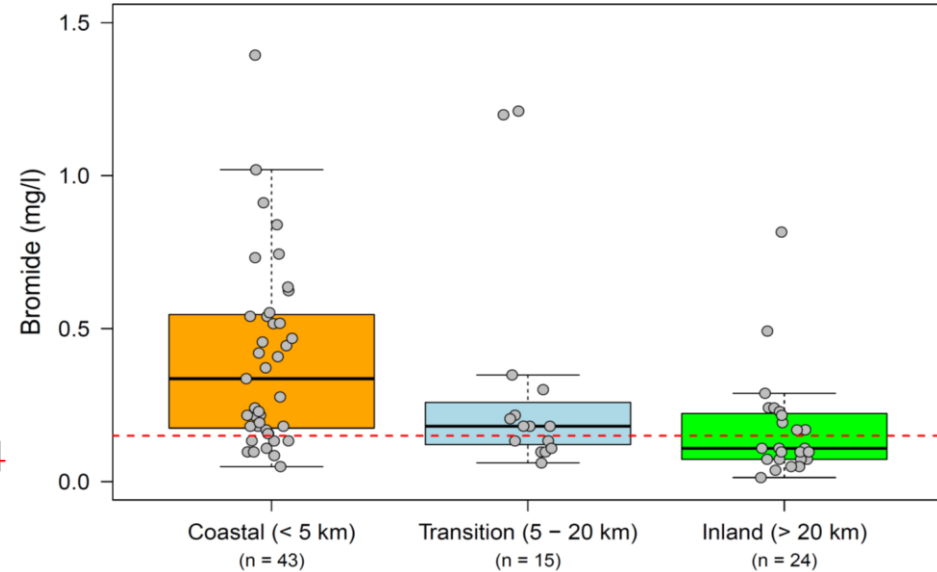
- Nitrite cause an additional ozone consumption of 3.43 mgO₃/mg-N
- Overall, nitrite concentrations in wastewater samples were low (sampling campaign spring/summer 2021)

Bromide

Bromide concentrations



WWTP distance to sea



Bromide < 0.15 mg/L will not cause relevant bromate formation at typical ozone doses
Elevated bromide levels can have multiple causes (e.g. industrial WW, seawater, ...)

Individual WWTP fitness-check



Fitness check for API elimination for WWTPXXX (CC)

CWPharma 2 WWTP code: CC_nn

November 2021

Prepared by:

Berlin Centre of Competence for Water (KWB)



Table of contents:

1) Current status of WWTP

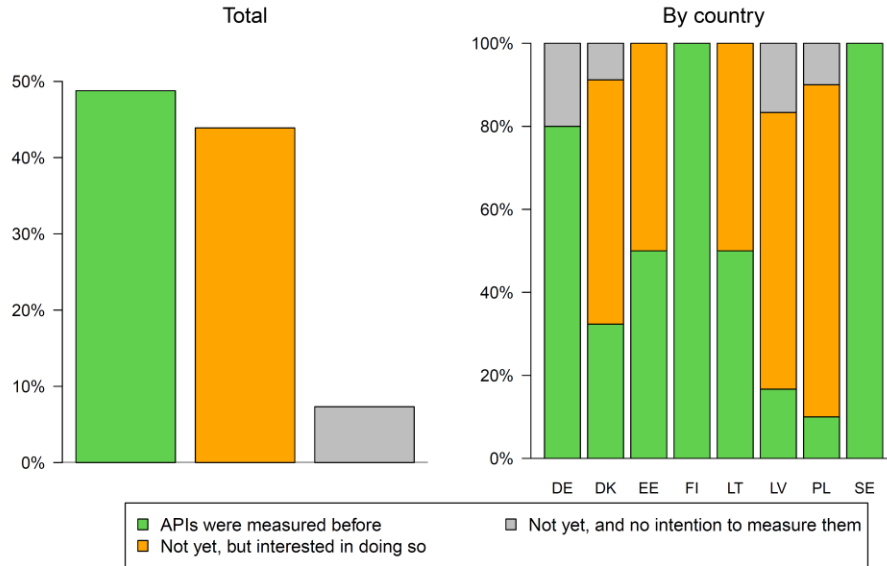
- Treatment process
- Water quality parameters
- **API concentrations**

2) Evaluation

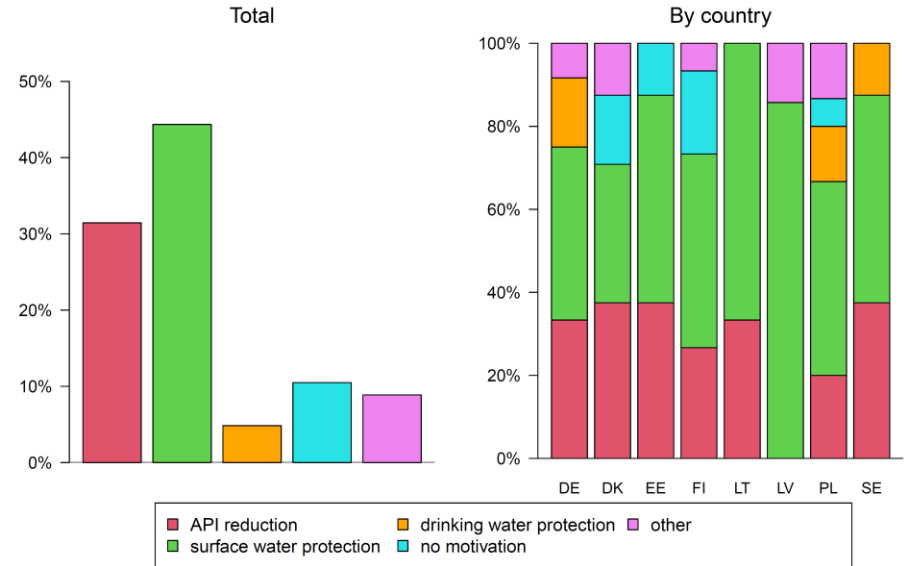
- **Risk evaluation**
- Data availability
- Expected PAC/ozone dosages
- Barriers for API elimination technologies
- Interaction with other treatment goals (synergies)
- (Optional) use of existing infrastructure

Feedback on APIs experiences / motivation

Experience in measuring APIs



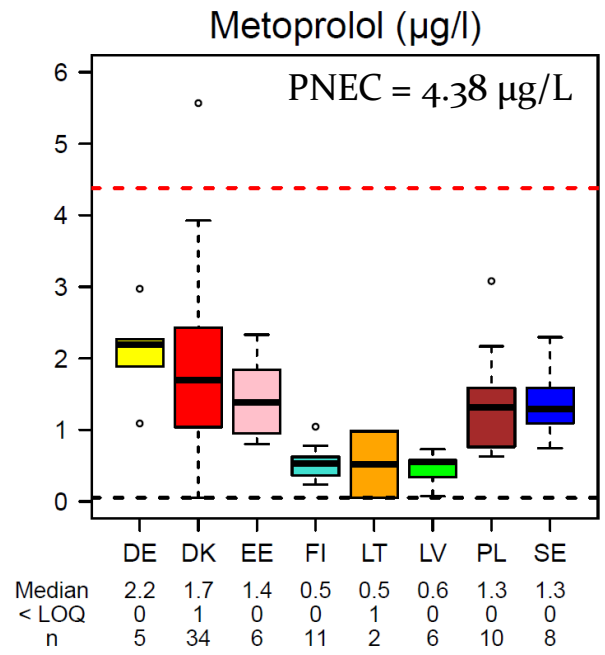
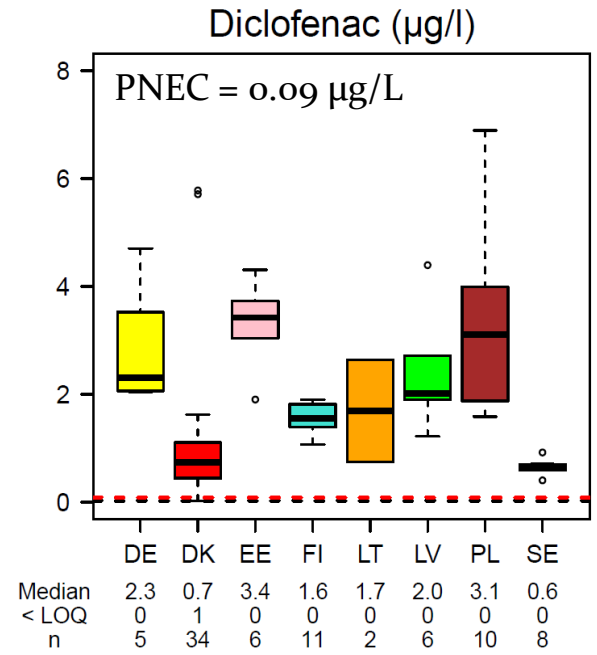
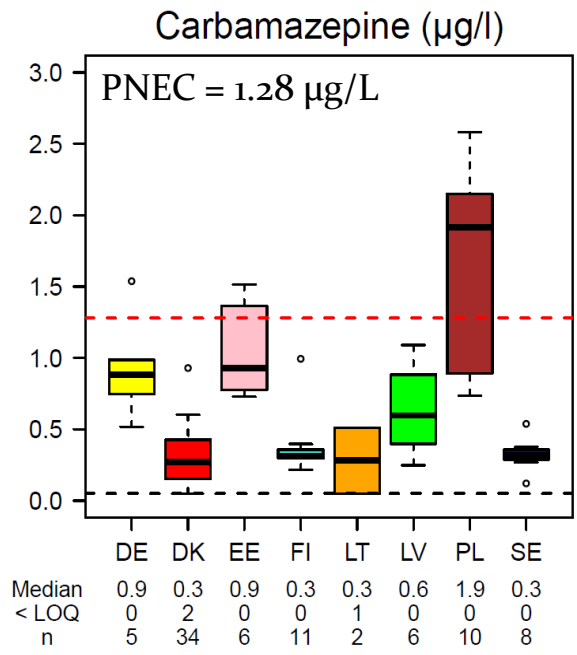
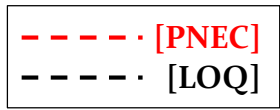
Motivation for API reduction



High coverage also due to research programs

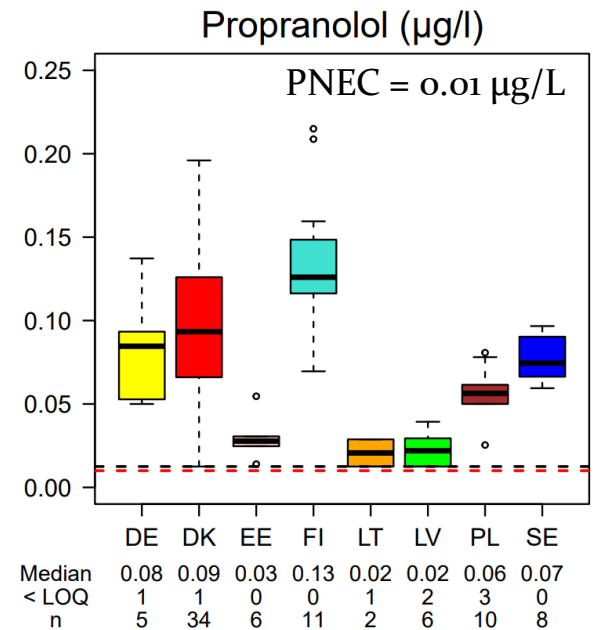
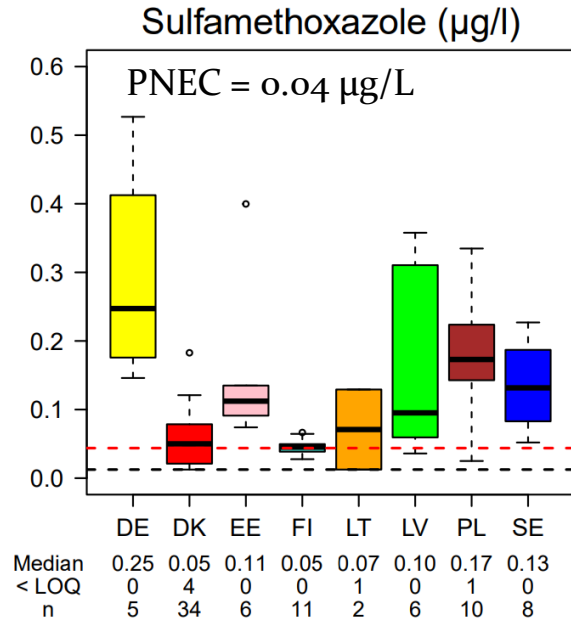
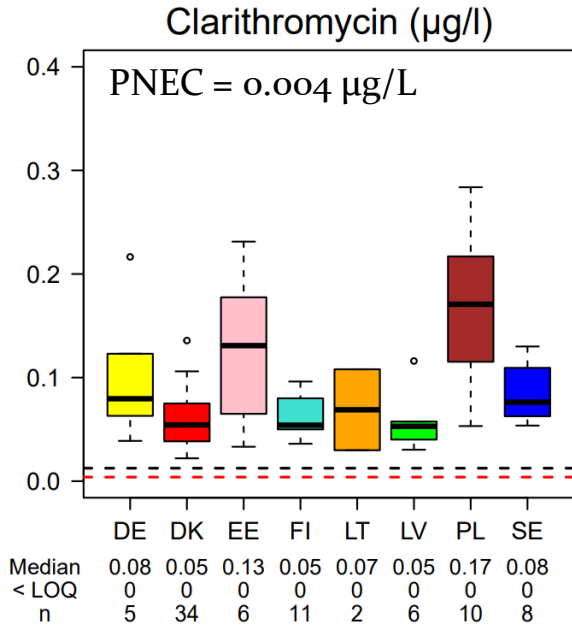
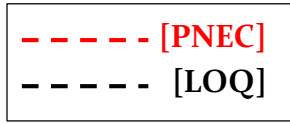
Highest motivation:
 - surface water protection
 - general API reduction

APIs at WWTP effluent



Predicted no effect concentration (PNEC) here based on CWPharma overview.
 → PNEC depend on data availability and might change in the future

Further APIs exceeding PNECs

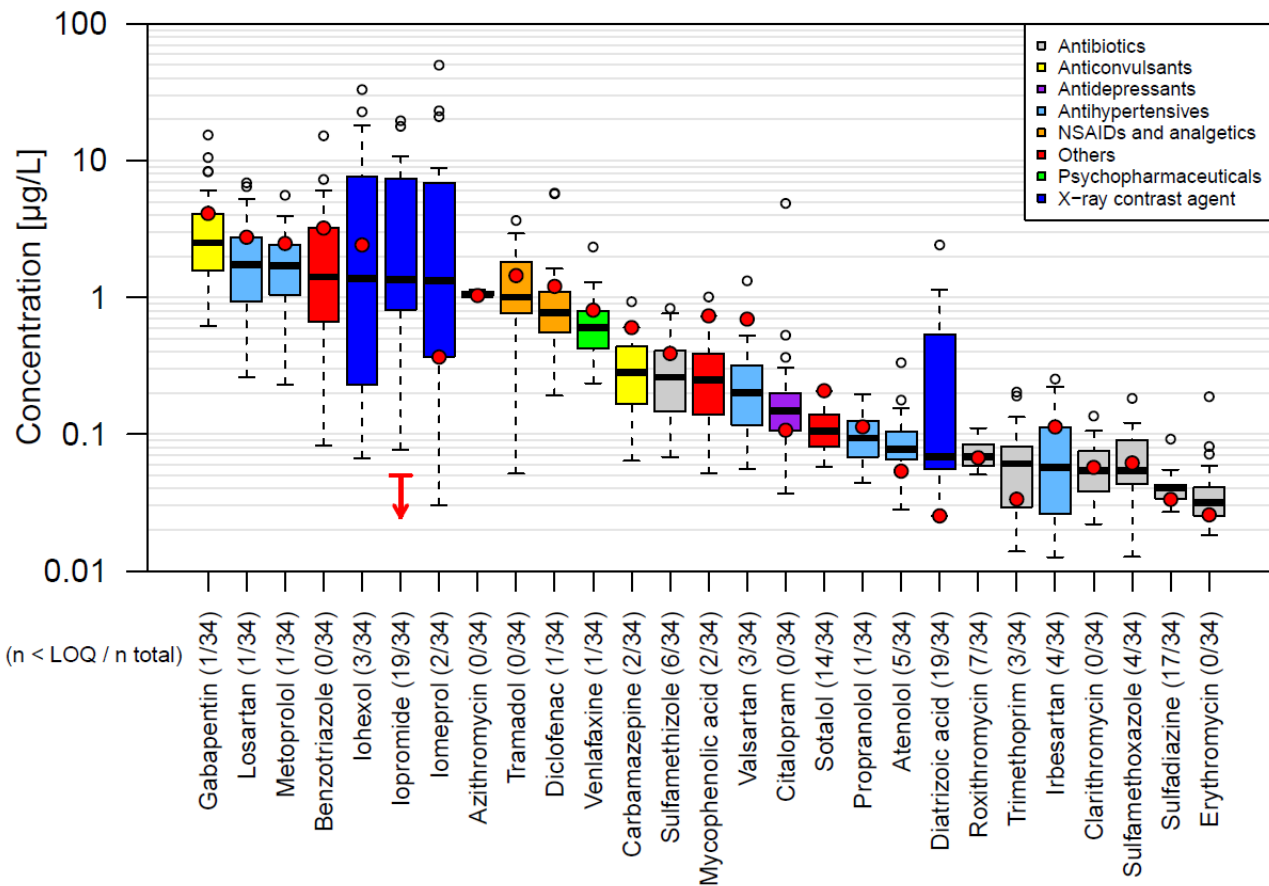


APIs that were often below LOQ:

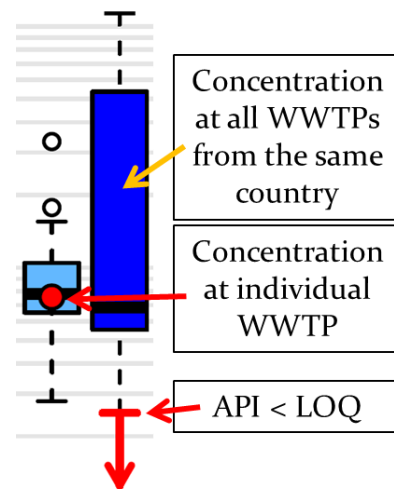
Candesartan (100%), Ciprofloxacin (100%), Clindamycin (96%), Eprosartan (93%), Phenazone (93%), and Iopamidol (84%)

➔ Complete results will be available in the summary report

APIs at fitness-check (example from DK)



How to read:



➔ Need for API elimination derived by of risk quotient:

$$\begin{aligned}
 RQ &= PEC / PNEC \\
 &= C_{API,i} / PNEC_{API,I} \\
 &\quad \text{(w/o dilution)}
 \end{aligned}$$

Individual WWTP fitness-check



Fitness check for API elimination for WWTPXXX (CC)

CWPharma 2 WWTP code: CC_nn

November 2021

Prepared by:

Berlin Centre of Competence for Water (KWB)



Table of contents:

1) Current status of WWTP

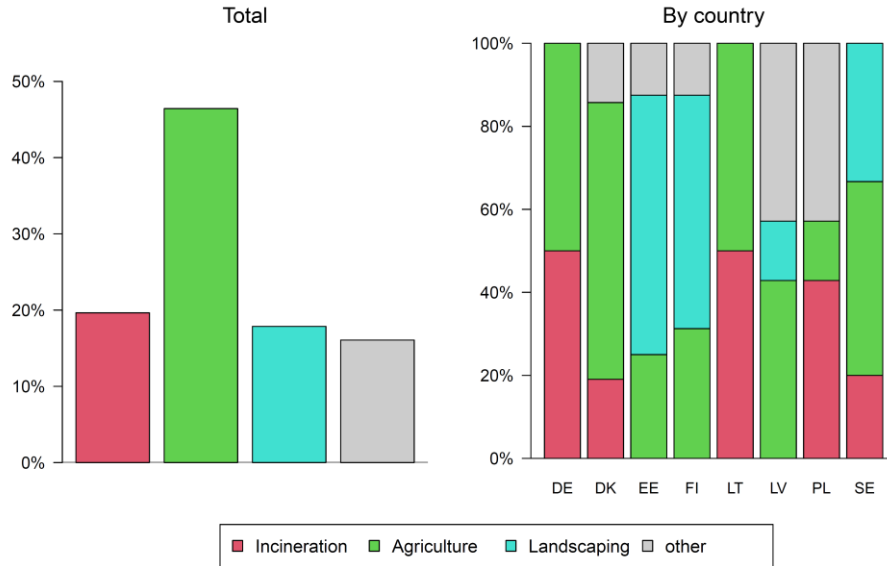
- Treatment process
- Water quality parameters
- API concentrations

2) Evaluation

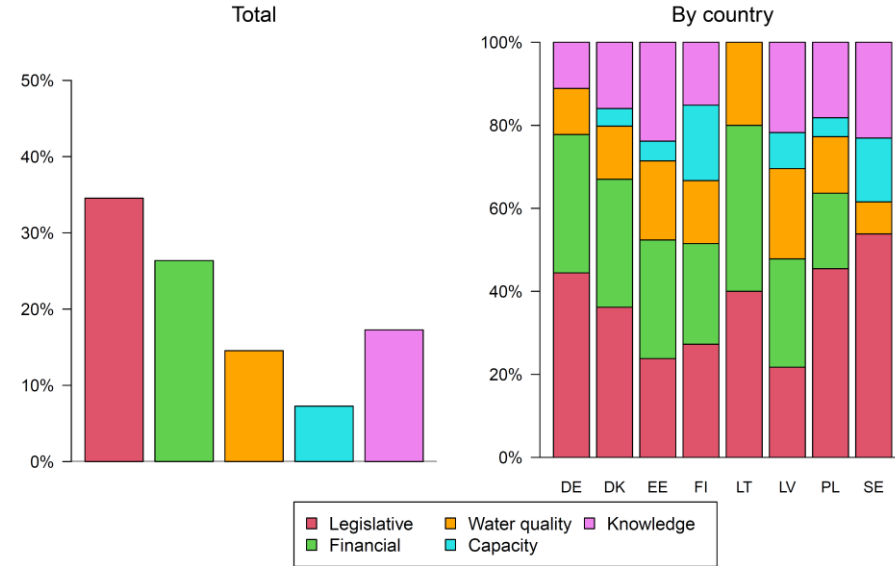
- Risk evaluation
- Data availability
- Expected PAC/ozone dosages
- **Barriers for API elimination technologies**
- Interaction with other treatment goals (synergies)
- (Optional) use of existing infrastructure

Barriers for API elimination

Disposal of treated sewage sludge



Barriers for implementation of API removal technology



Potential barriers:

- sludge disposal (**bad for PAC**)
- elevated nitrite/bromide levels (**bad for ozone**)
- high loads of industrial WW (**do lab tests**)

Some feedbacks:

- What are the „right“ APIs to focus on?
- Expected high costs need to be justified
- API elimination vs. carbon footprint
- Insufficient space

Individual WWTP fitness-check



Fitness check for API elimination for WWTPXXX (CC)

CWPharma 2 WWTP code: CC_nn

November 2021

Prepared by:

Berlin Centre of Competence for Water (KWB)



Table of contents:

1) Current status of WWTP

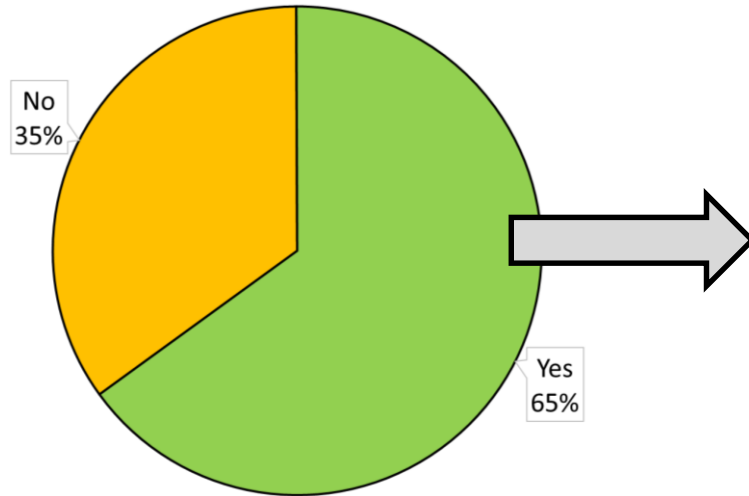
- Treatment process
- Water quality parameters
- API concentrations

2) Evaluation

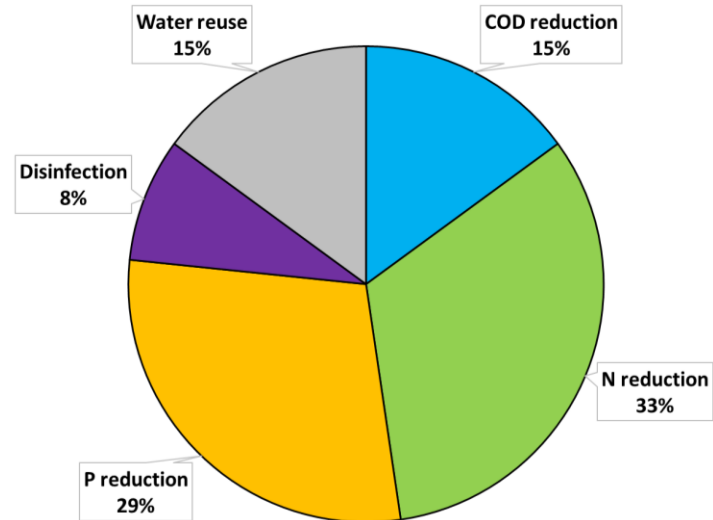
- Risk evaluation
- Data availability
- Expected PAC/ozone dosages
- Barriers for API elimination technologies
- Interaction with other treatment goals (synergies)
- (Optional) use of existing infrastructure

Synergies with other goals / existing infra.

Interested in implementing measures within next 5 years?



Which measures (multiple choice)?



- Synergies with C and P reduction as well as disinfection/water reuse possible
- Synergies with N reduction limited, ozonation difficult with post-DN
- ~ 25% WWTPs have post-filtration: Check usage for AC (e.g. PAC retention, exchange with GAC) or ozonation post-treatment

Summary CWPharma 2 fitness-check



CWPharma 2
CLEAR WATERS FROM PHARMACEUTICALS

WWTP fitness check for tertiary treatment

GoA2.1: Fitness check for API removal technology

Coming soon



AARHUS UNIVERSITY
KOMPETENZENTRUM Wasser Berlin
Umwelt Bundesamt
KALUNDBORG UTILITY
LATVIJAS HIDROEKOLOĢIJAS INSTITŪTS
ESTONIAN ENVIRONMENTAL RESEARCH CENTRE
IEP-NRI
Hillerød Forsyning
HSY
Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
FLAGSHIP

- Evaluation of ~ 80 WWTPs based on questionnaire and wastewater sample
- Fitness-check reports are being / have been sent to participating WWTPs
- Summary report will be published in December 2021

Thank you for listening

Any questions? Feel free to contact us:

E-Mail: michael.stapf@kompetenz-wasser.de

KWB: <https://www.kompetenz-wasser.de/en/>

CWPharma 2-Homepage: <https://projects.au.dk/waterpurification/cwpharma-2/>



KOMPETENZZENTRUM
Wasser Berlin



EUROPEAN UNION

EUROPEAN
REGIONAL
DEVELOPMENT
FUND