



Water reuse in agriculture: Exploiting synergies with the German national micropollutant strategy

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Agricultural water reuse in Europe: status, challenges and opportunities for further growth

Water Reuse Europe | Webinar | 27 June 2023

WavE and WavE II

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Federal Ministry of Education and Research

FONA

Research for sustainability

Future-oriented Technologies & Concepts to Increase Water Availability by Water Reuse & Desalination (“WavE”)

An Initiative of the Federal Ministry of Education and Research

WavE

WATER. REUSE. DESALINATION.

- Duration: **2016-2021**
- Funding volume: ~ **32 Mio. €**
- 13 collaborative projects

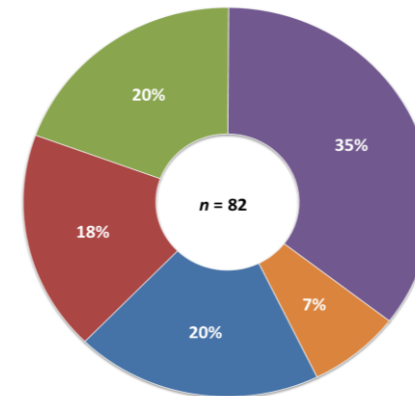
Water Technologies: Reuse (“WavE II“)

An Initiative of the Federal Ministry of Education and Research

WavE

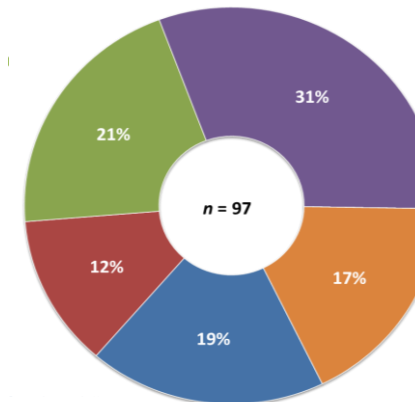
Water Technologies: Reuse

- Duration: **2021-2024**
- Funding volume : ~ **25 Mio. €**
- 13 collaborative projects



Partners involved:

- Large companies
- SMEs
- Research facilities
- Universities
- Other (associations, authorities...)



Networking and Transfer Project



DECHEMA

Gesellschaft für Chemische Technik und Biotechnologie e.V.

www.bmbf-wave.de

(Upcoming) European Union legal framework



Water protection

Several EU directives will be amended

- Water Framework Directive
- Groundwater Directive
- Environmental Quality Standards Directive
- **Urban Wastewater Treatment Directive**

Published **proposals** also demand **micropollutant** removal at WWTPs with >100.000 p.e.
(> 10.000 p.e. in sensitive areas)

Established technologies (in DE & CH)

- Ozonation (n ≥ 20)
- Powdered activated carbon (n ≥ 25)
- Granular activated carbon (n ≥ 13)



Water reuse

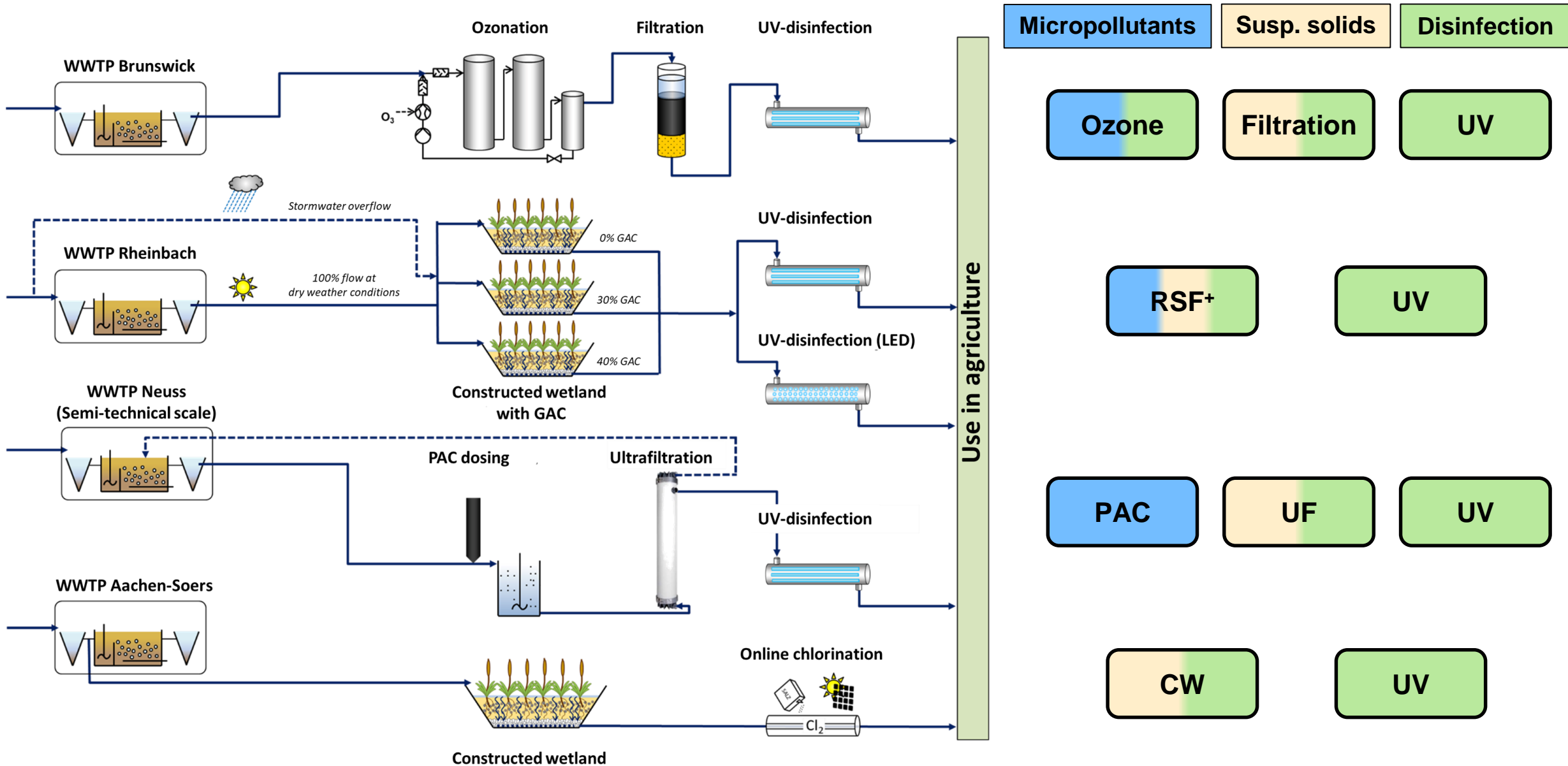
Minimum requirements for water reuse in agriculture were defined in EU Regulation 2020/741 (will be enforced from 26.06.2023)

Treatment targets focus on microbiological indicator parameters / disinfection

Reclaimed water quality class	Indicative technology target	<i>E. coli</i> (number/100 ml)
A	Secondary treatment, filtration, and disinfection	≤ 10
B	Secondary treatment, and disinfection	≤ 100
C	Secondary treatment, and disinfection	≤ 1 000
D	Secondary treatment, and disinfection	≤ 10 000

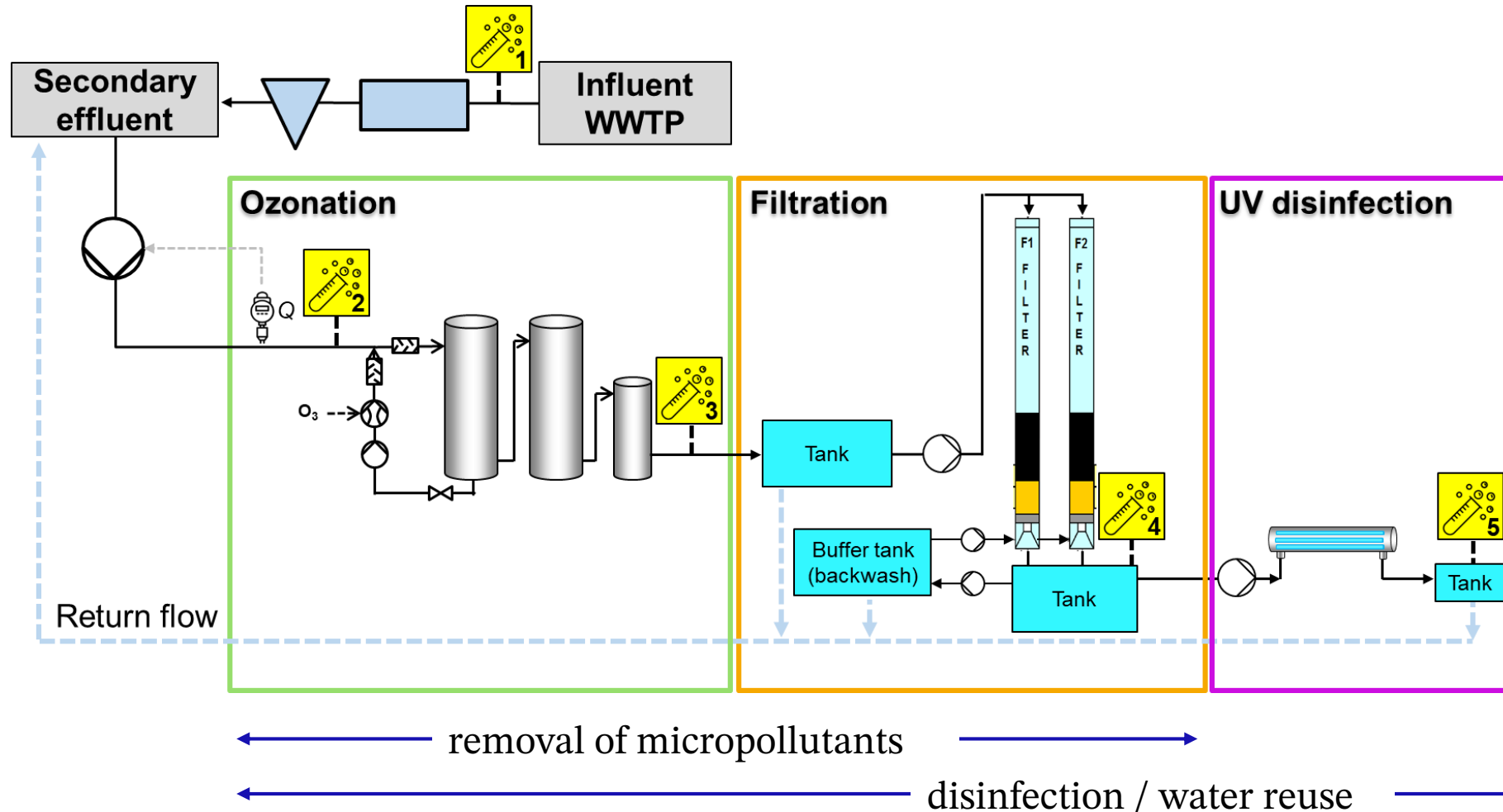
(EU regulation 2020/741, table 2 – shortened)

FlexTreat: case studies



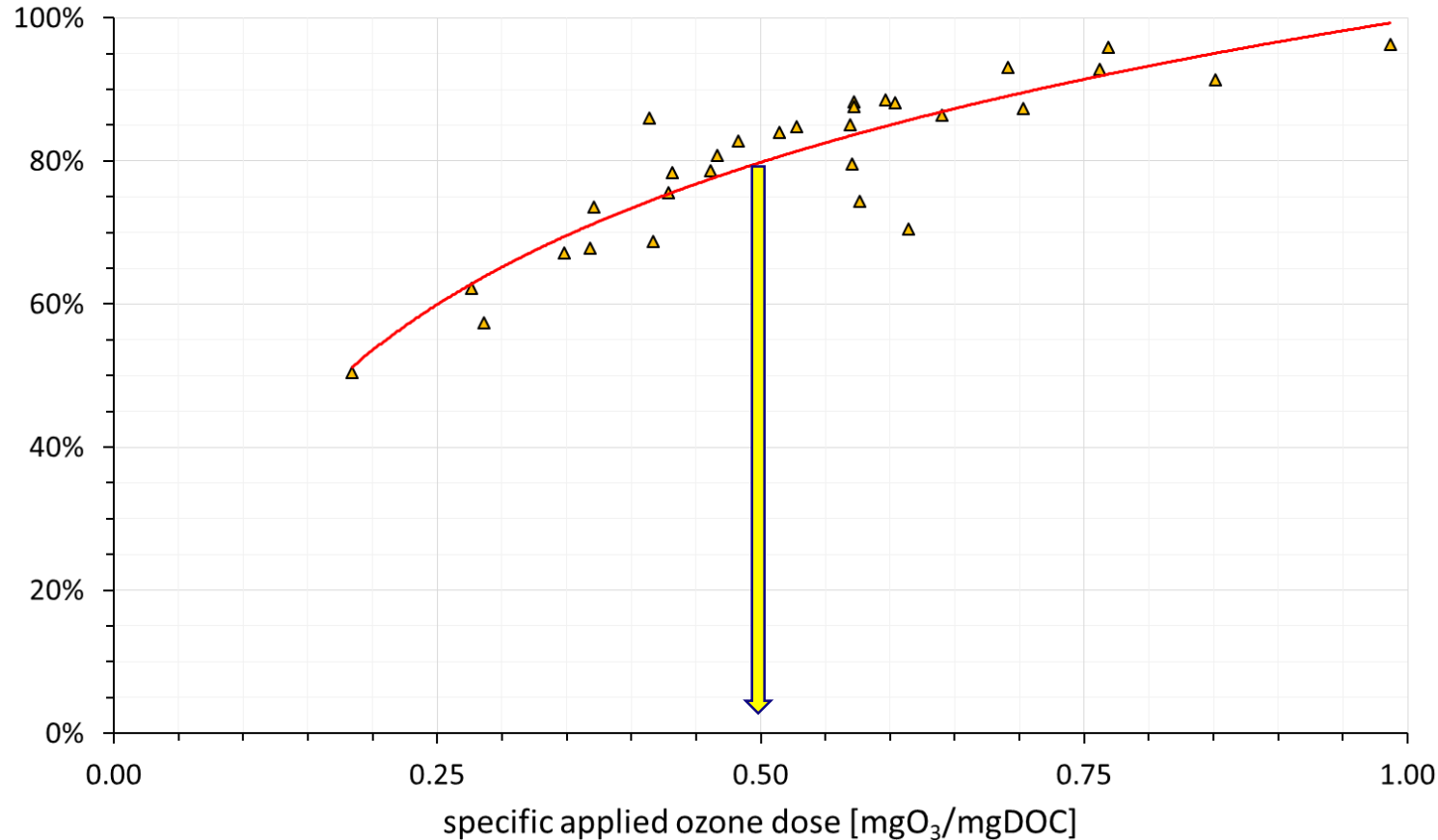
Capitalize on synergy effects

If **removal of micropollutants** is mandatory (e.g. via ozonation or activated carbon), then it's just a small step further to **achieve water reuse**



Impact of ozonation

Estimated micropollutants reduction according to UWWTD proposal*

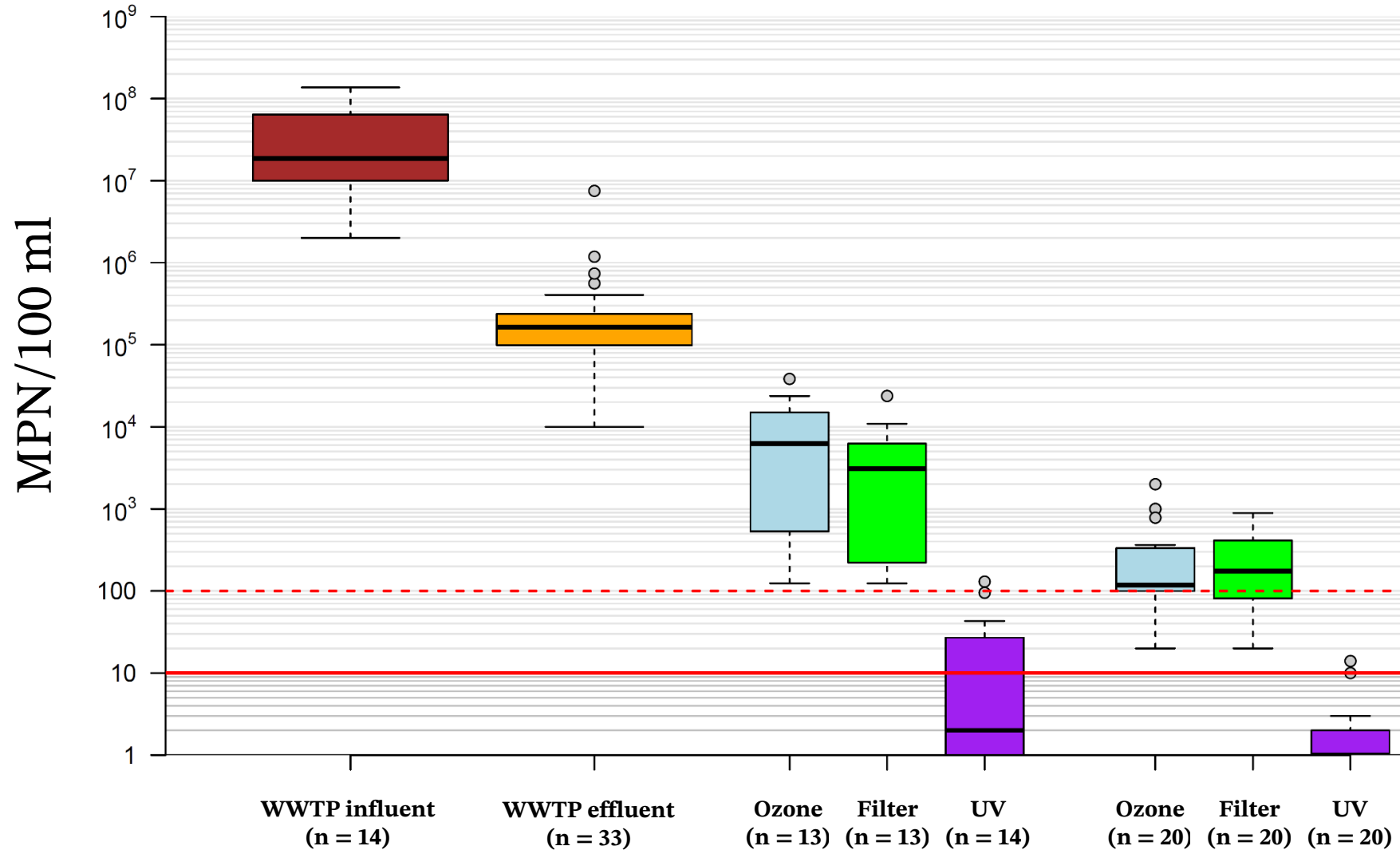


Ozonation using 0.5 mgO₃/mgDOC:

- Sufficient for micropollutant removal according to UWWTD requirements (and also according to targets of two federal states within Germany)
- Dosing in line with actual operation of full scale ozone systems (incl. degradation of activated sludge system)
- Question:
 - Is Class A water quality possible?

**preliminary
results**

Disinfection: *E. coli*



Target:
LRV > 5 log

Class A (unrestricted irrigation) max. limit

90% of samples

$\Delta UVA_{254} = 34\%$
(~ 0.4 mgO₃/mgDOC)

$\Delta UVA_{254} = 47\%$
(~ 0.7 mgO₃/mgDOC)

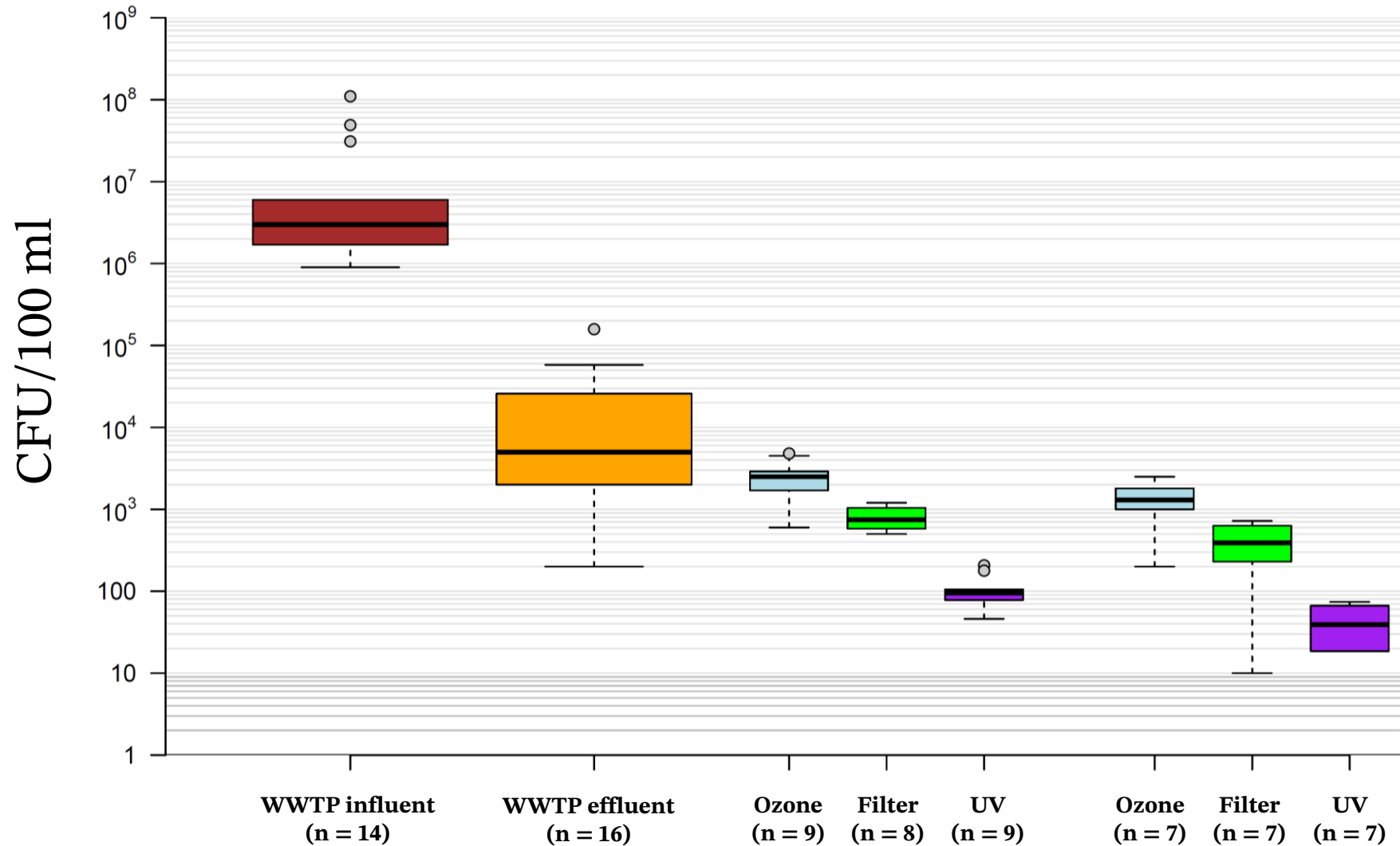
preliminary results

Disinfection: *Clostridium perfringens*

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Target:
LRV > 4 log

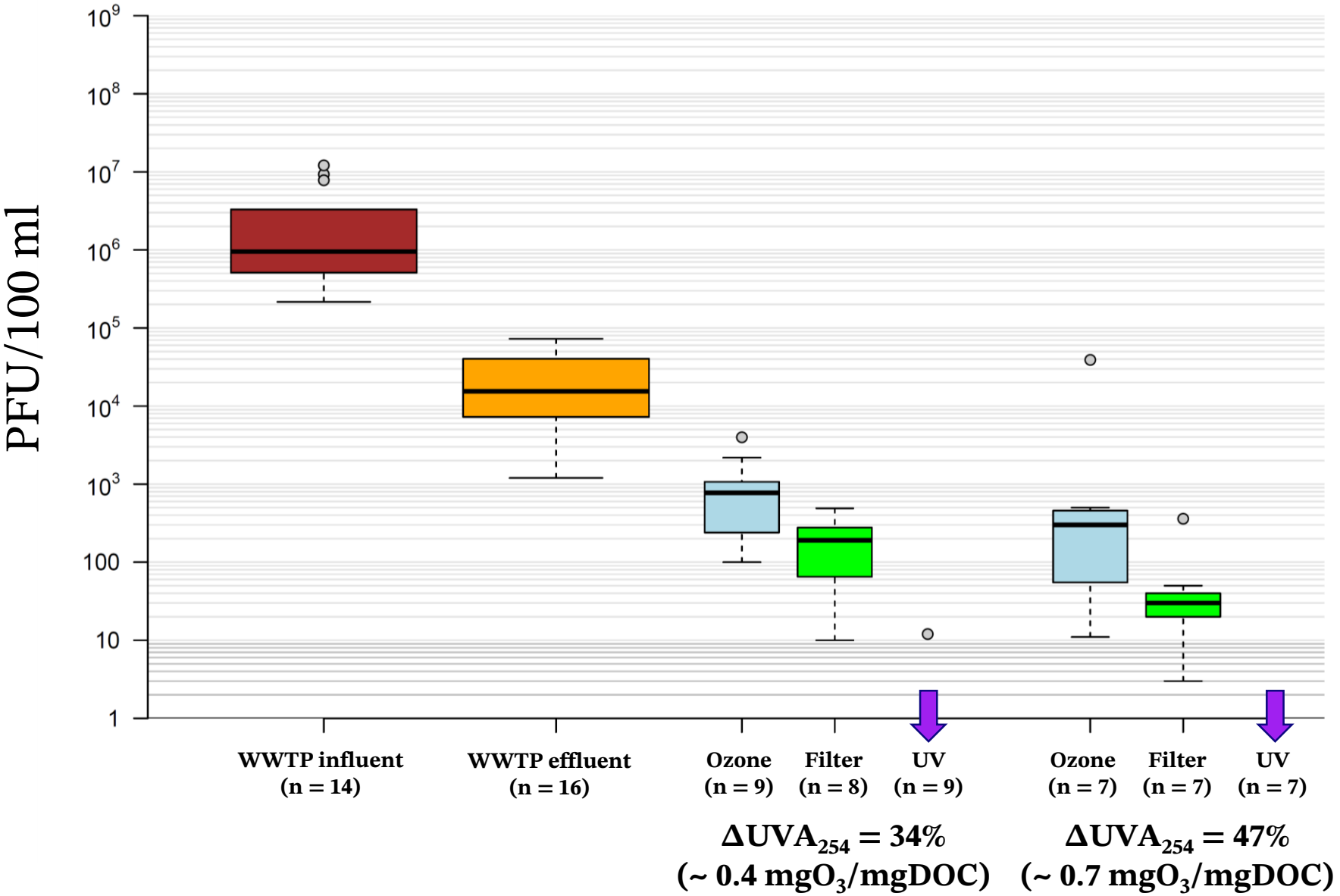
$\Delta UVA_{254} = 34\%$
(~ 0.4 mgO₃/mgDOC) $\Delta UVA_{254} = 47\%$
(~ 0.7 mgO₃/mgDOC)

**preliminary
results**

Disinfection: Somatic coliphages



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Target:
LRV > 6 log

Most measurements after UV disinfection were 0

preliminary results

Class A: Validation monitoring

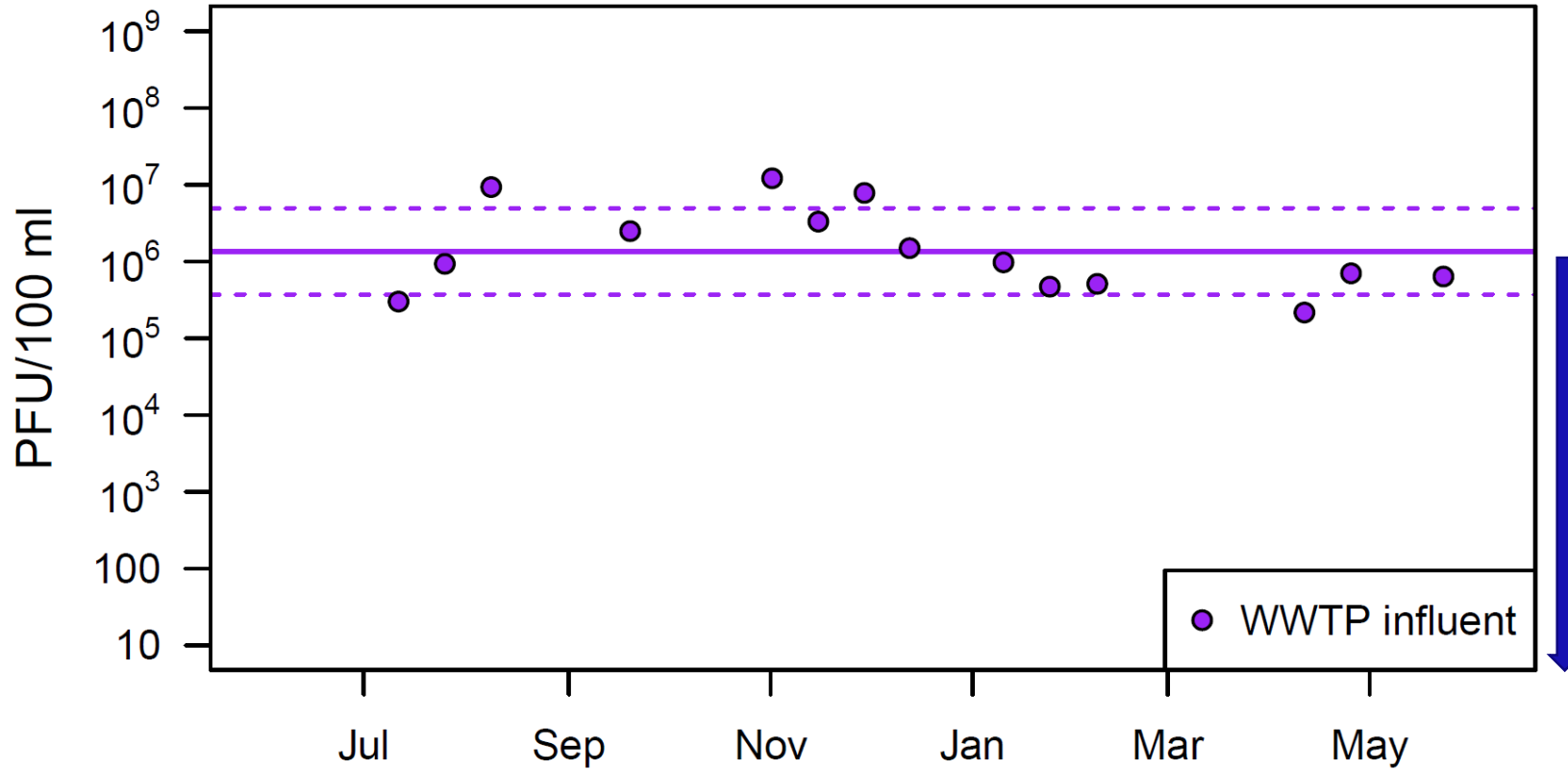
REGULATION (EU) 2020/741 on minimum requirements for water reuse

- **At least 90 % of validation samples** shall reach or exceed the performance targets.
- If a biological indicator is **not present in sufficient quantity in raw waste water** to achieve the log₁₀ reduction, the **absence of such biological indicator** in reclaimed water shall mean that the validation requirements are complied with.
- The compliance with the performance target may be established by **analytical control**, by **addition of the performance granted to individual treatment steps** based on scientific evidence for standard well-established processes, such as published data of testing reports or case studies, or **tested in a laboratory under controlled conditions for innovative treatment**.

Guidelines to support the application of Regulation 2020/741 on minimum requirements for water reuse (2022/C 298/01)

- For microbial monitoring, it is important to perform analysis on a number of samples that is statistically valid – so **at least three samples** at each sample point to allow the calculation of averages and standard deviations.
- It is suggested that **standard deviation should be less than 1 log₁₀** among the samples.
- At least **90 % of samples** should meet the performance targets.
- The **frequency and duration of validation monitoring** should be established on the basis of the protocol developed for the specific case.

Presence of Somat. Coliphage

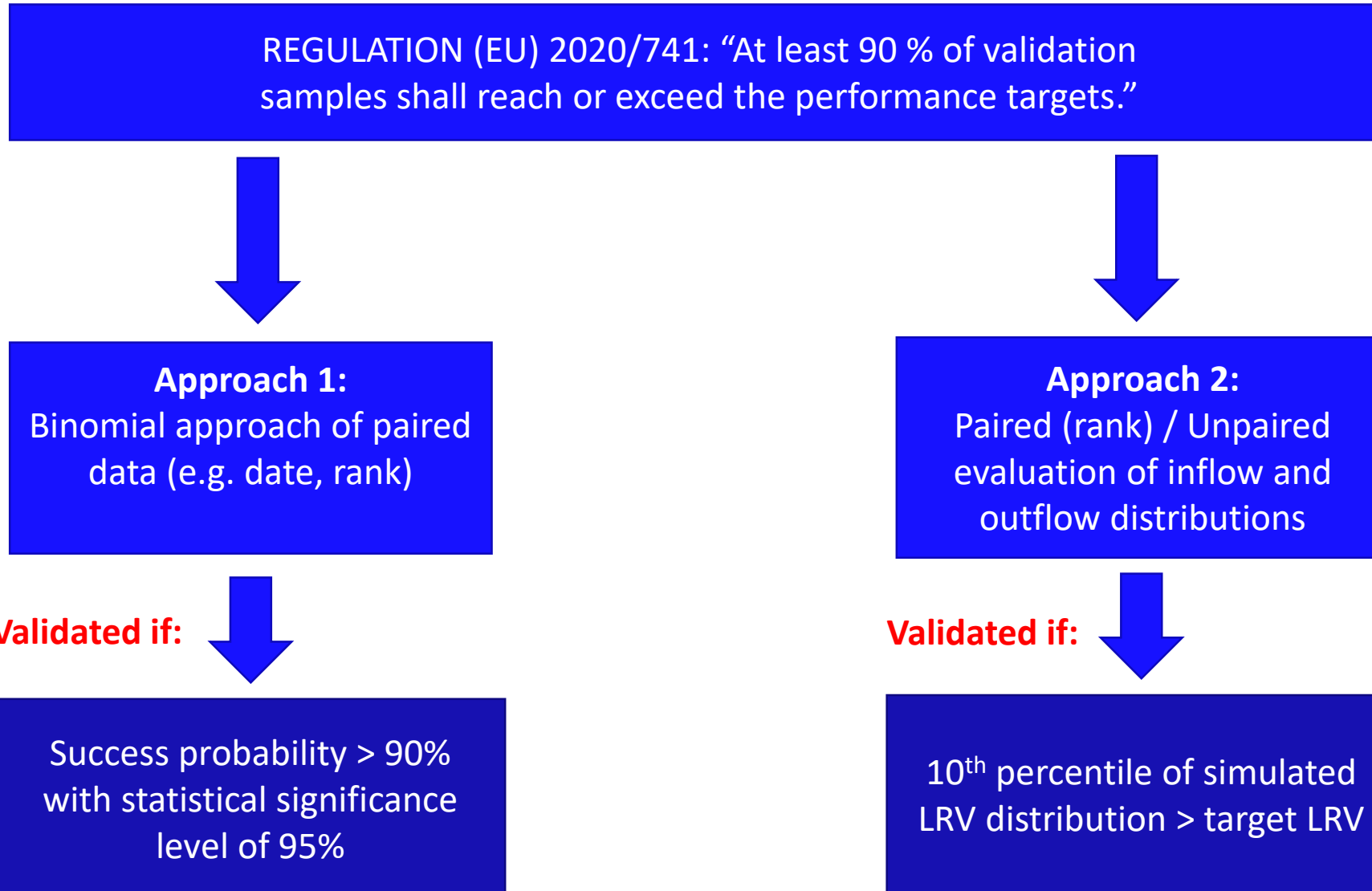


Standard deviation: 0.5 log

6 log possible ???

**preliminary
results**

Statistical approaches for log - removal evaluation



preliminary
results

Example: Somat. Coliphages

Data selection for performance validation:

- 24 h mixed samples
- Effluent 14 samples
- Influent 16 samples
- No difference is made between low/high ozone dosage → one data set
- Approach 1: Only paired data used for evaluation → 13 sample pairs
- Approach 2: all data used

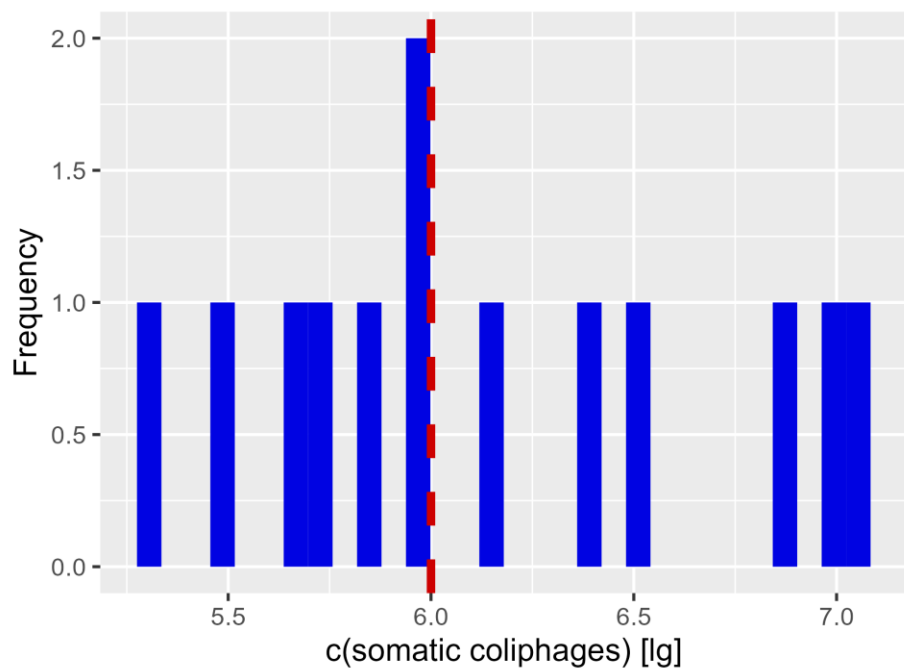
Other assumptions

- EU: If $< 10^6$ in influent and $< 10^0$ in effluent = validation successful
 - We decided to ignore this option, as most likely not accepted by German health authorities
 - Instead: If $< 10^6$ in influent and LOQ for effluent is 10^0 → validation not successful

Example: Coliphages (Approach 1)

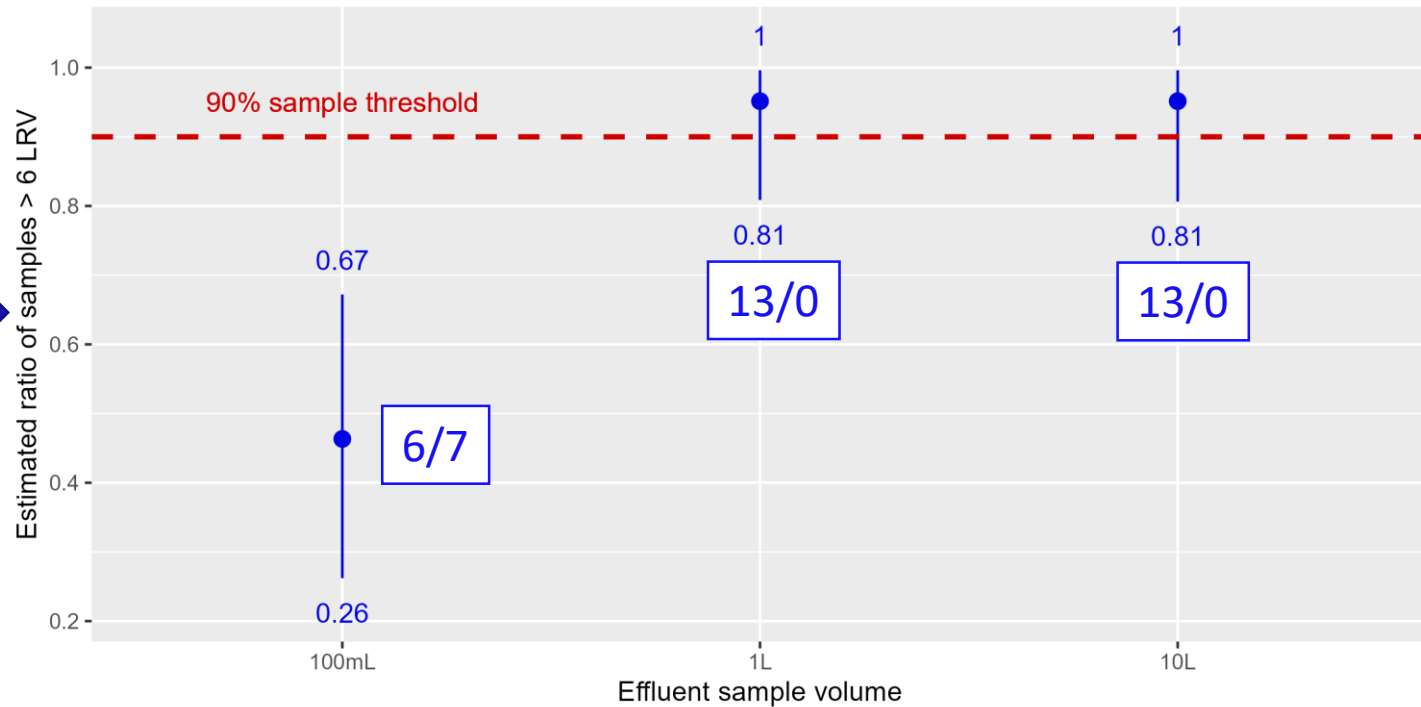
Histogram of inflow data somatic coliphages

13 Observations



Increase of effluent sample volume

Effect of increased sample volume on LRV validation
Evaluation on binomial approach

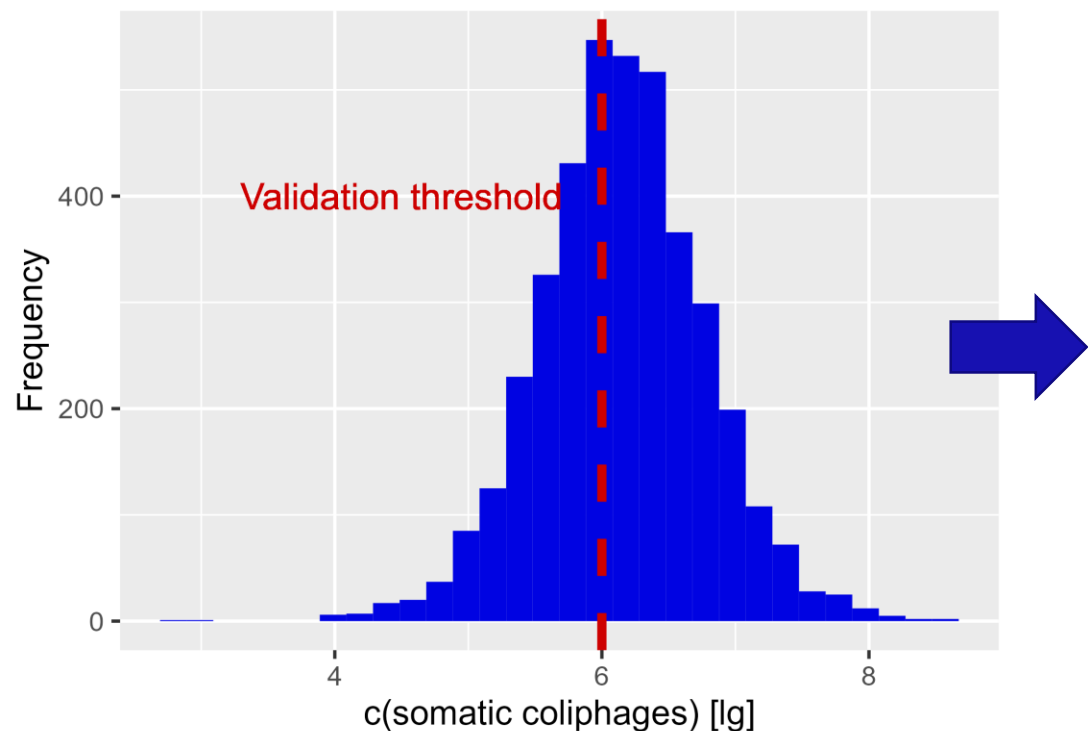


Problem:
 Only 50% (6/13) of influent data $> 10^6$
 All effluent values $< 10^0$ PFU/100 mL
Assumption: if influent $< 10^6 \rightarrow$ no success

Solution approach:
 Increase of sample volume not sufficient for proper validate
 at 95 % confidence level: **29 success samples necessary**

Example: Coliphages (Approach 2)

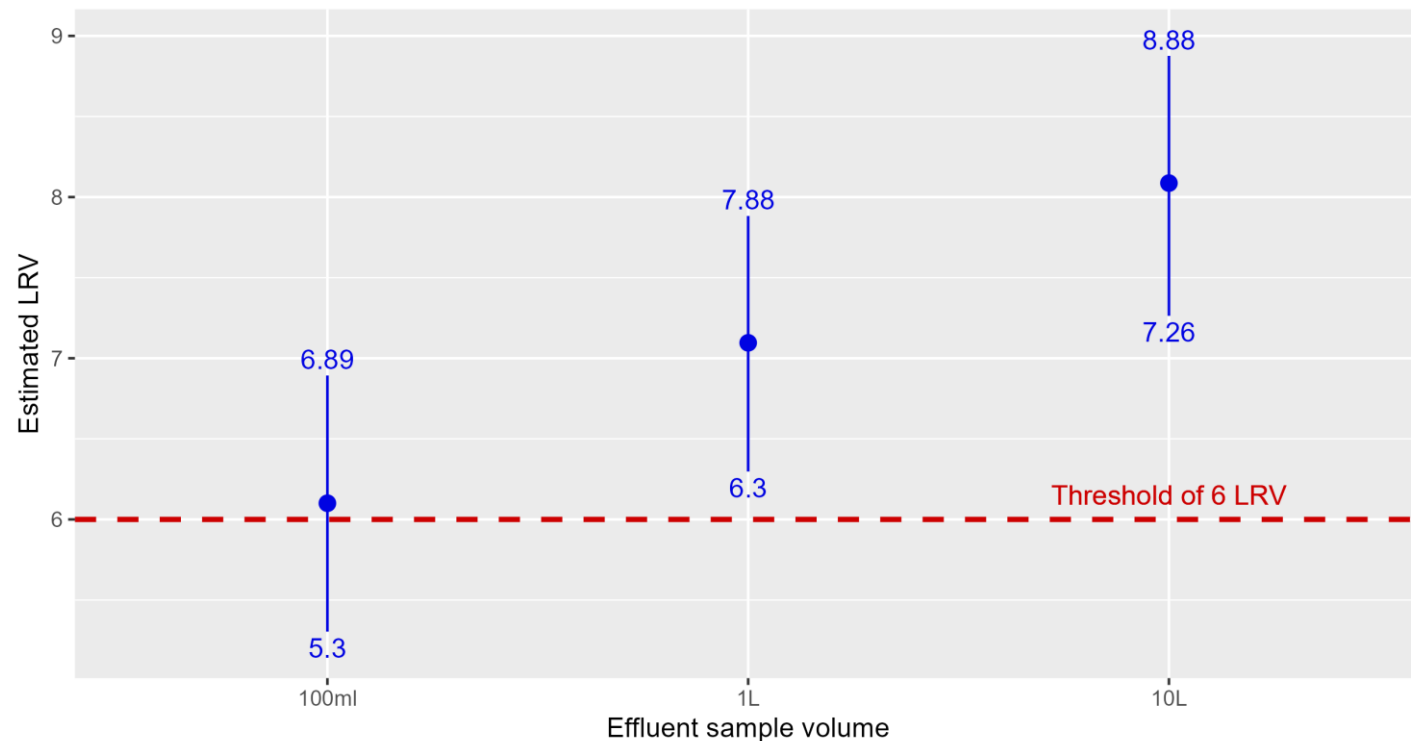
Inflow distribution of somatic coliphages
Lognormal model fitted to 14 data points



Problem:
Only 50% of influent data > 10^6

Increase of effluent sample volume

Effect of increased sample volume on LRV validation



Solution approach:
Increase of effluent sample volume allows for proper numeric validation
(assumption: effluent below LOQ for all volumes)

Conclusions

- Micropollutant removal and treatment for water reuse have significant synergy effects
- Ozonation designed for micropollutant removal increases the overall disinfection performance
- Combining ozone & filtration as pre-treatment results in reliable UV disinfection
- Validation of log removal values
 - Different approaches for data evaluation possible
 - Success rate based on paired samples requires much more samples to provide a 95 % confidence level
 - Success rate based on paired samples has limited benefit from increased sample volume
 - Evaluation of inflow and outflow distributions has several advantages (use of full data set, direct response to increased sampling volume, considers absolute levels of LRV)

Acknowledgements

Authors (all KWB):

M. Stapf (Ozonation & disinfection trials)

W. Seis (Statistics & LRV validation)

U. Mieke

Thanks for on-site piloting, sampling and analytics:

- J. Heinze, B. Lennhoff (Abwasserverband Braunschweig),
- N. Hermes (Bundesanstalt für Gewässerkunde),
- L. Freier, N. Zacharias (Institut für Hygiene und Öffentliche Gesundheit/ Public Health),
- S. Bottke, B. Fiebig (Stadtentwässerung Braunschweig),
- M. Fassbender, J. Gebhardt (Xylem)



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