FACULTY OF
BIOSCIENCE ENGINEERING

OPTIMISATION OF ADVANCED OXIDATION PROCESSES IN VIEW OF ORGANIC (MICRO)POLLUTANT REMOVAL FROM (WASTE) WATER IN VIEW OF WATER REUSE

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MICROPOLLUTANT REMOVAL

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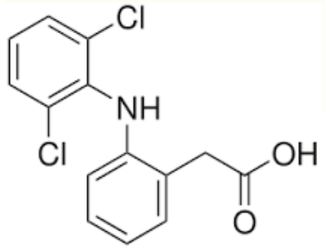
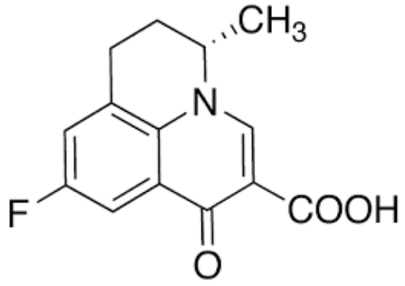
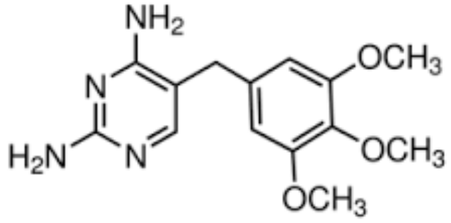


Diclofenac
(Pain relief)



Flumequine
(antibiotic)

(antibiotic)



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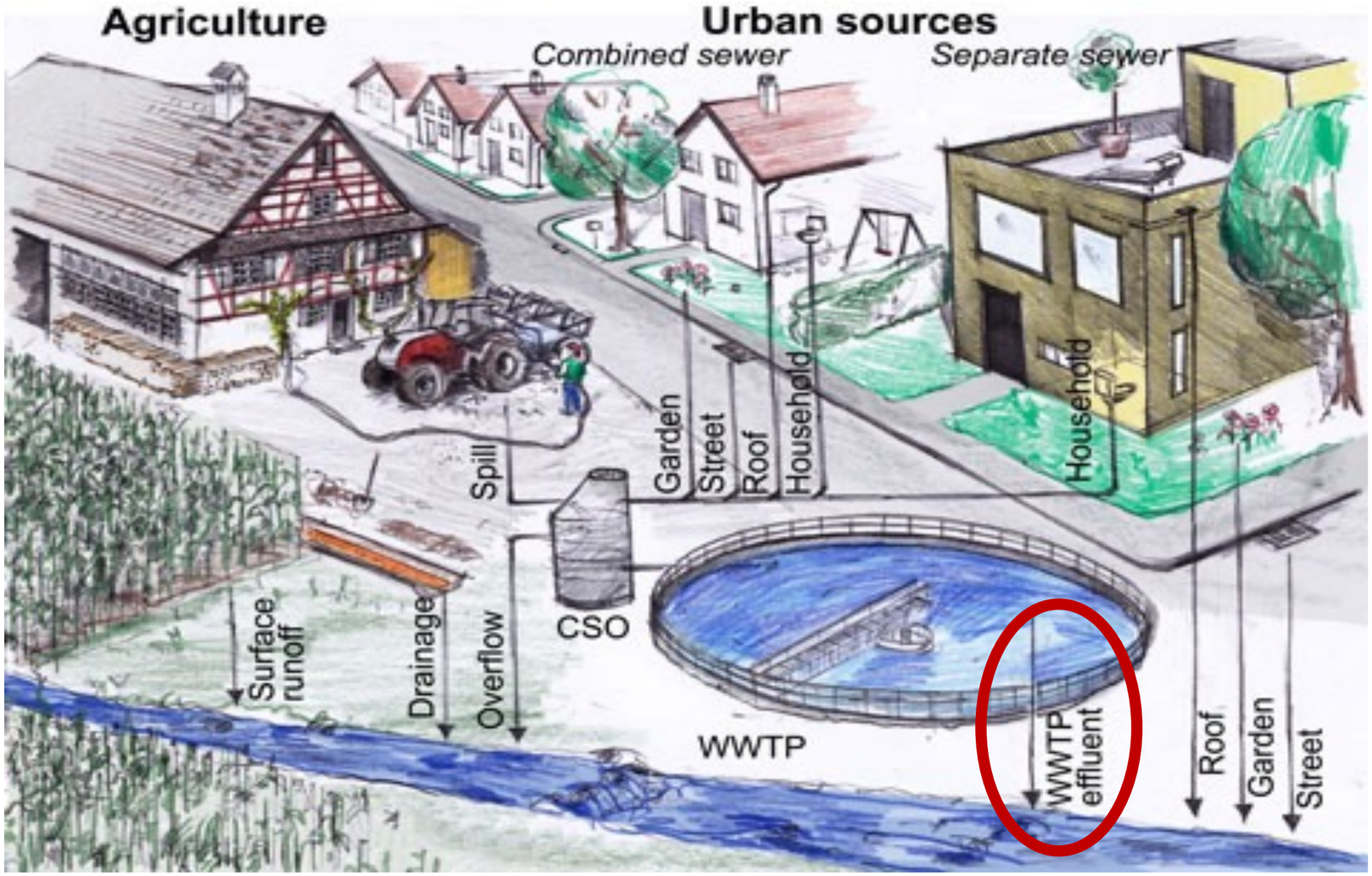
MICROPOLLUTANT REMOVAL

– Sources



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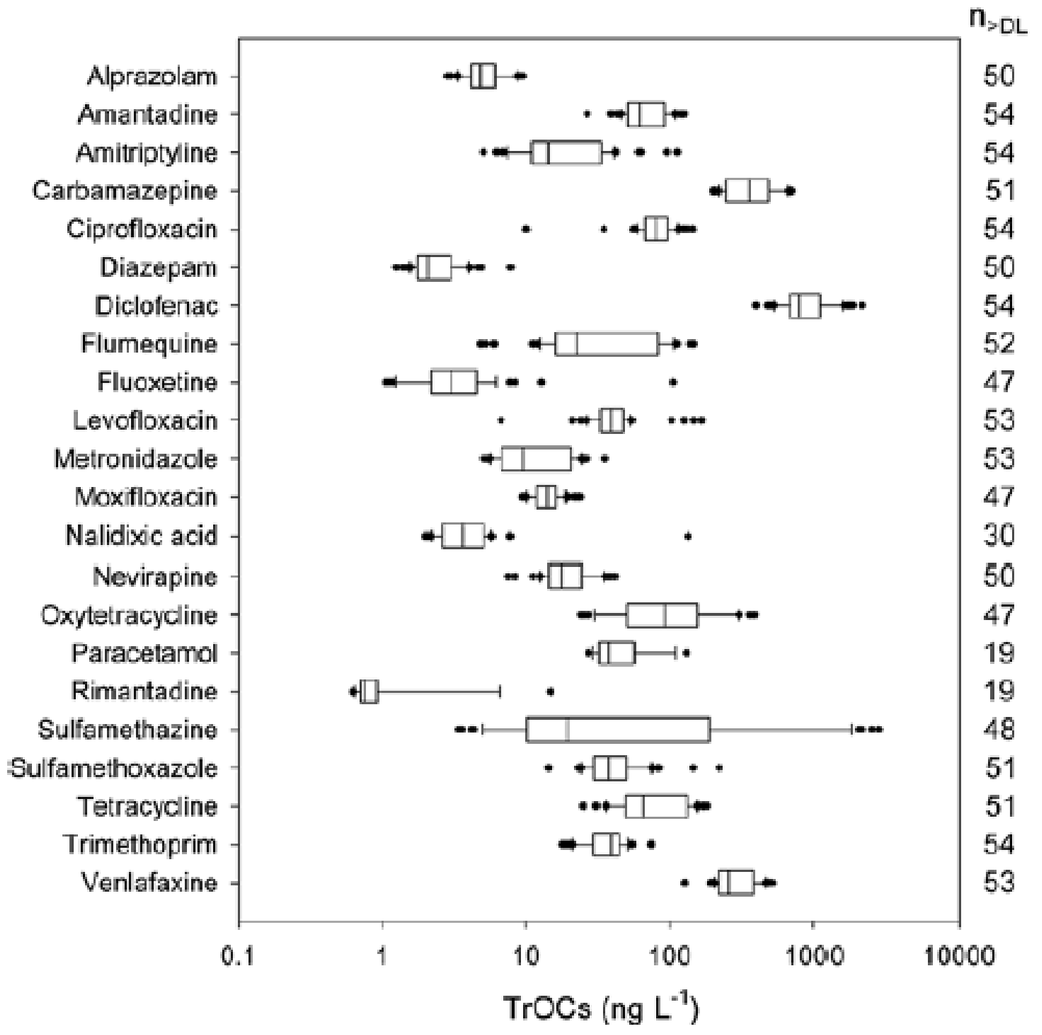
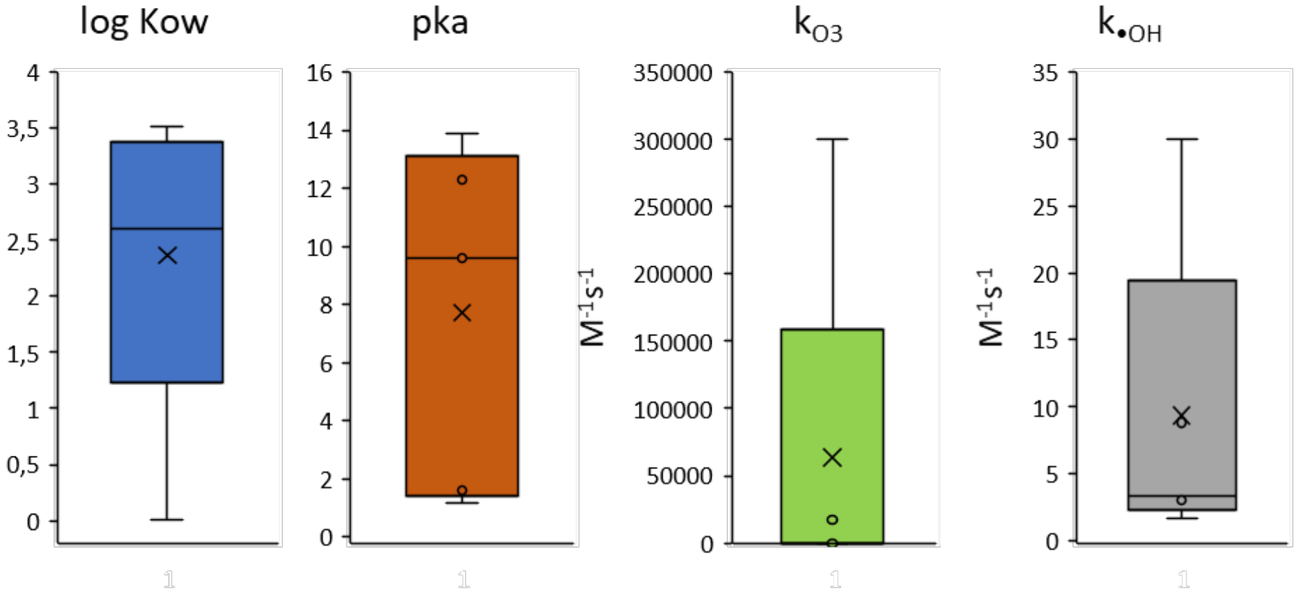
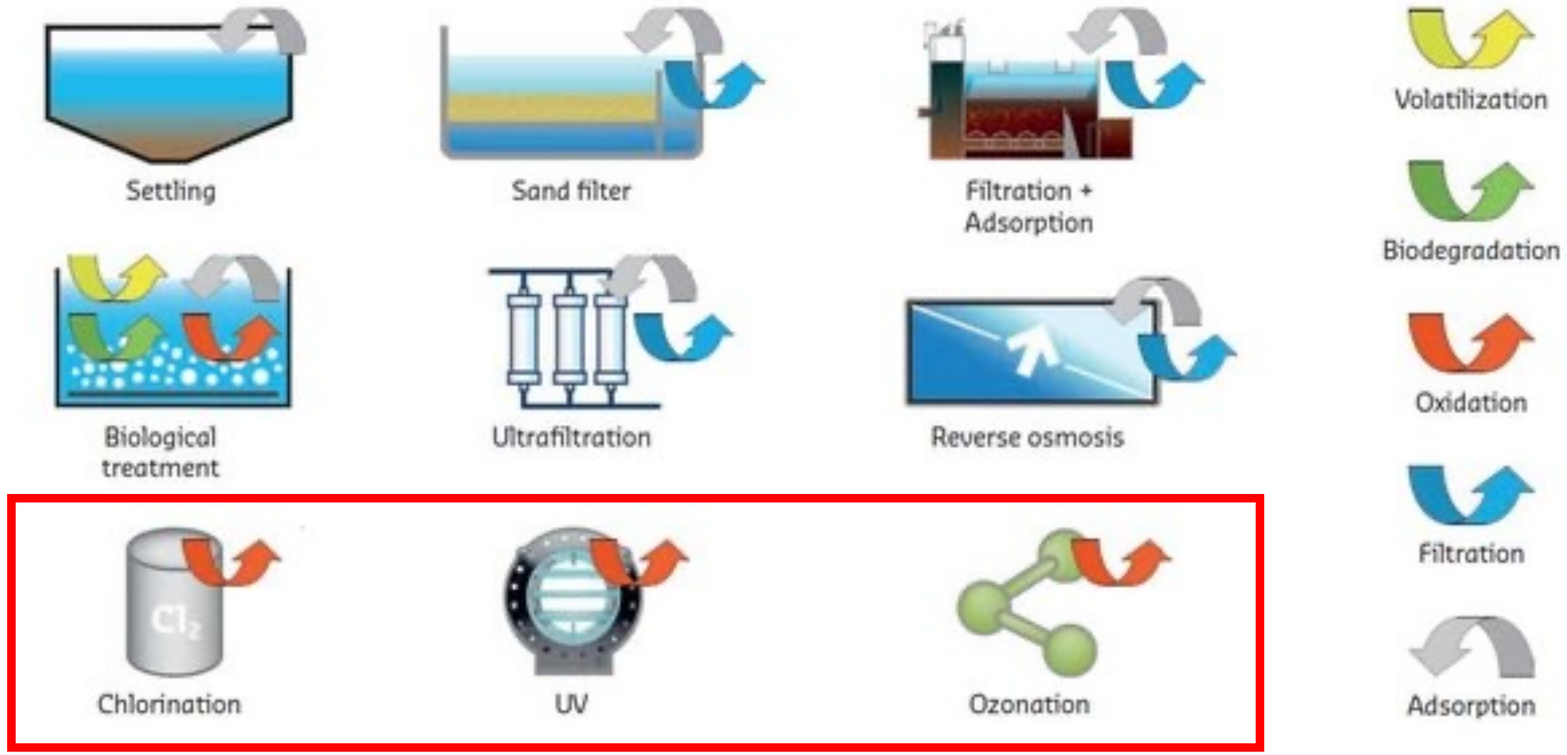


Fig. 3. Concentration levels (ng L^{-1}) of 22 TrOCs, quantified in minimum 20% of all samples. The whiskers of the boxplots indicate the 10th and 90th percentile of the data distribution, while the black dots are the outliers considering all measured data. The quantification frequency is indicated on the right indicating the total number of samples in which the TrOC was measured above the detection limit ($n_{>DL}$, see Vergeynst et al., 2017).



MICROPOLLUTANT REMOVAL

- Removal
  - “Law of conservation of misery”
  - Limited biodegradation



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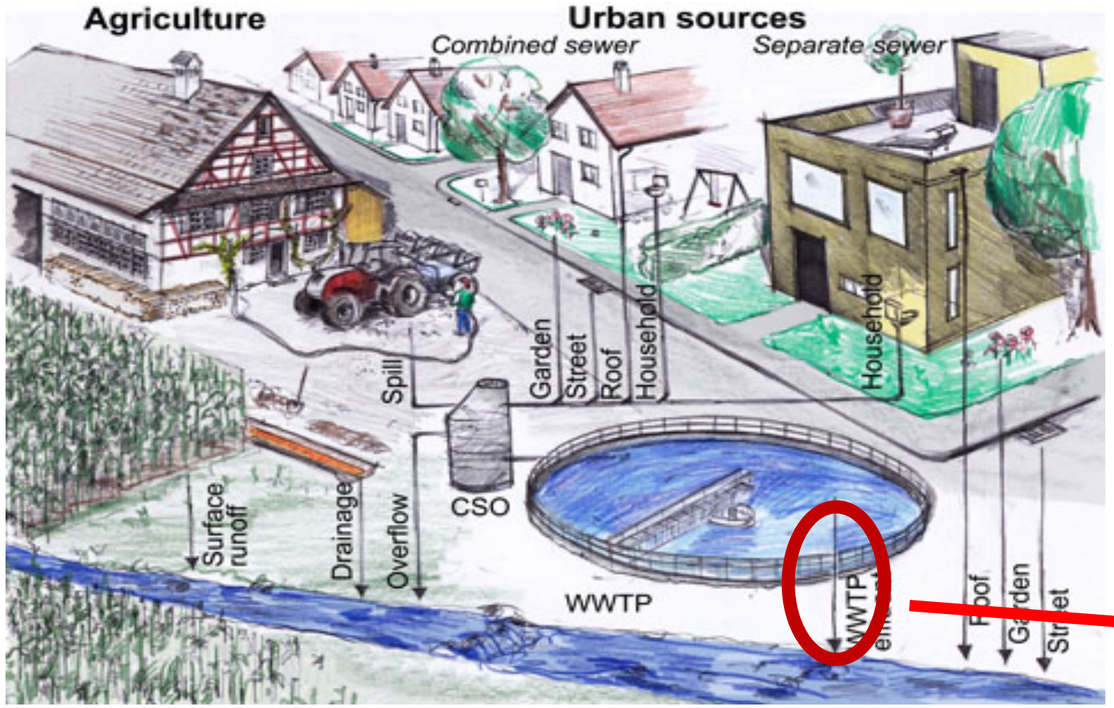
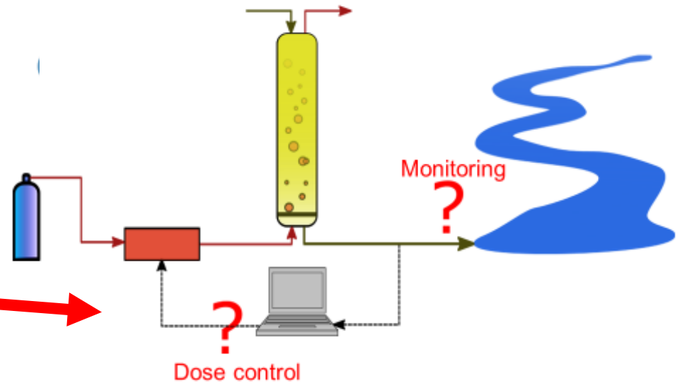
MICROPOLLUTANT REMOVAL

- Possible solutions
  - Tertiary treatment with ozone based processes





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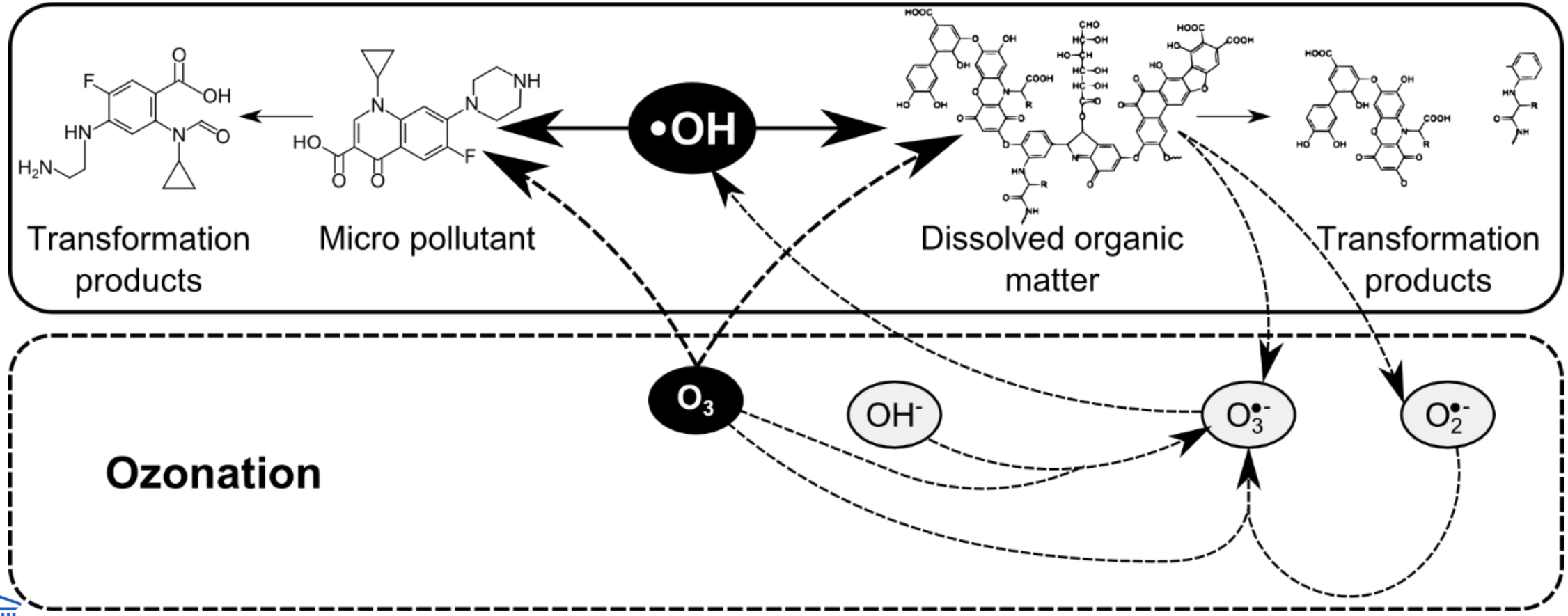
MICROPOLLUTANT REMOVAL

– Post-ozonisation



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MICROPOLLUTANT REMOVAL

- Post-ozonisation
  - Removal function of k_{O3}

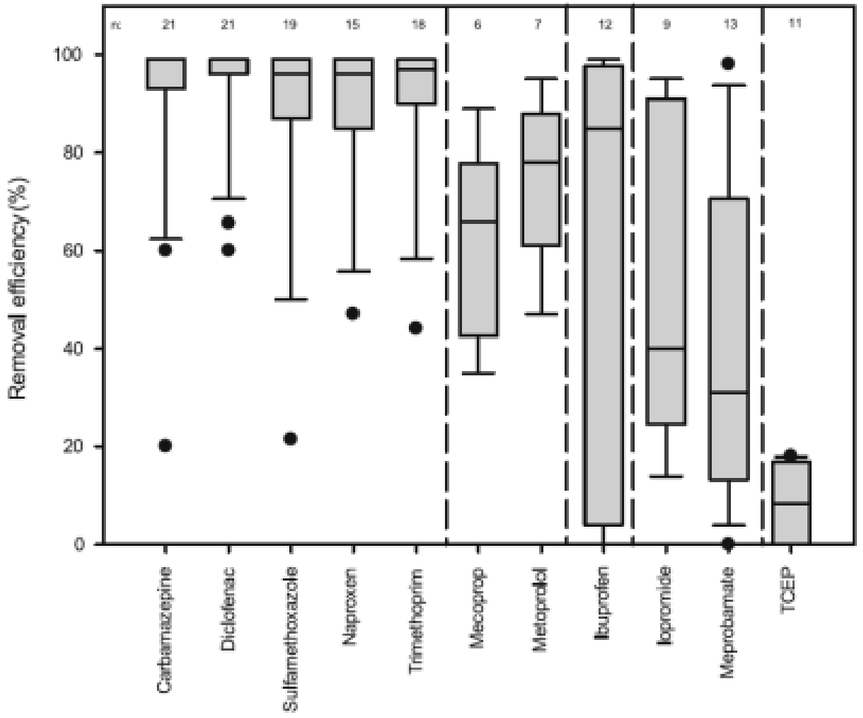

Fig. 2 Summary of removal efficiencies of TrOCs that can be classified as group I (carbamazepine, diclofenac, sulfamethoxazole, naproxen and trimethoprim), group II (mecoprop and metoprolol), group III (ibuprofen), group IV (iopromide and meprobamate) and group V (TCEP) compounds. Data is extracted from Blackbeard et al. (2016); Gerrity et al. (2012); Hollender et al. (2009); Leikam and Huber (2015); Park et al. (2017); Pisarenko et al. (2012); Singh et al. (2015); Snyder et al. (2006); Wert et al. (2009)

Table 1 Different groups of TrOCs defined by their specific second order reaction rate constants for both direct ($k_{O3,TrOC,pH7}$) and indirect ($k_{OH,TrOC,pH7}$) ozonation reactions (Gerrity et al. 2012; Lee et al. 2013)

Group	Description	$k_{O3,TrOC,pH7}$ (M^{-1} s^{-1})	$k_{OH,TrOC,pH7}$ (10^9 M^{-1} s^{-1})
I	High reactivity with both ozone and ·OH	$\geq 10^5$	≥ 5
II	Moderate reactivity with ozone and high reactivity with ·OH	$< 10^5$ and ≥ 10	≥ 5
III	Low reactivity with ozone and high reactivity with ·OH	< 10	≥ 5
IV	Low reactivity with ozone and moderate reactivity with ·OH	< 10	< 5 and ≥ 1
V	Low reactivity with both ozone and ·OH	< 10	< 1

PRE-AND POST FILTRATION

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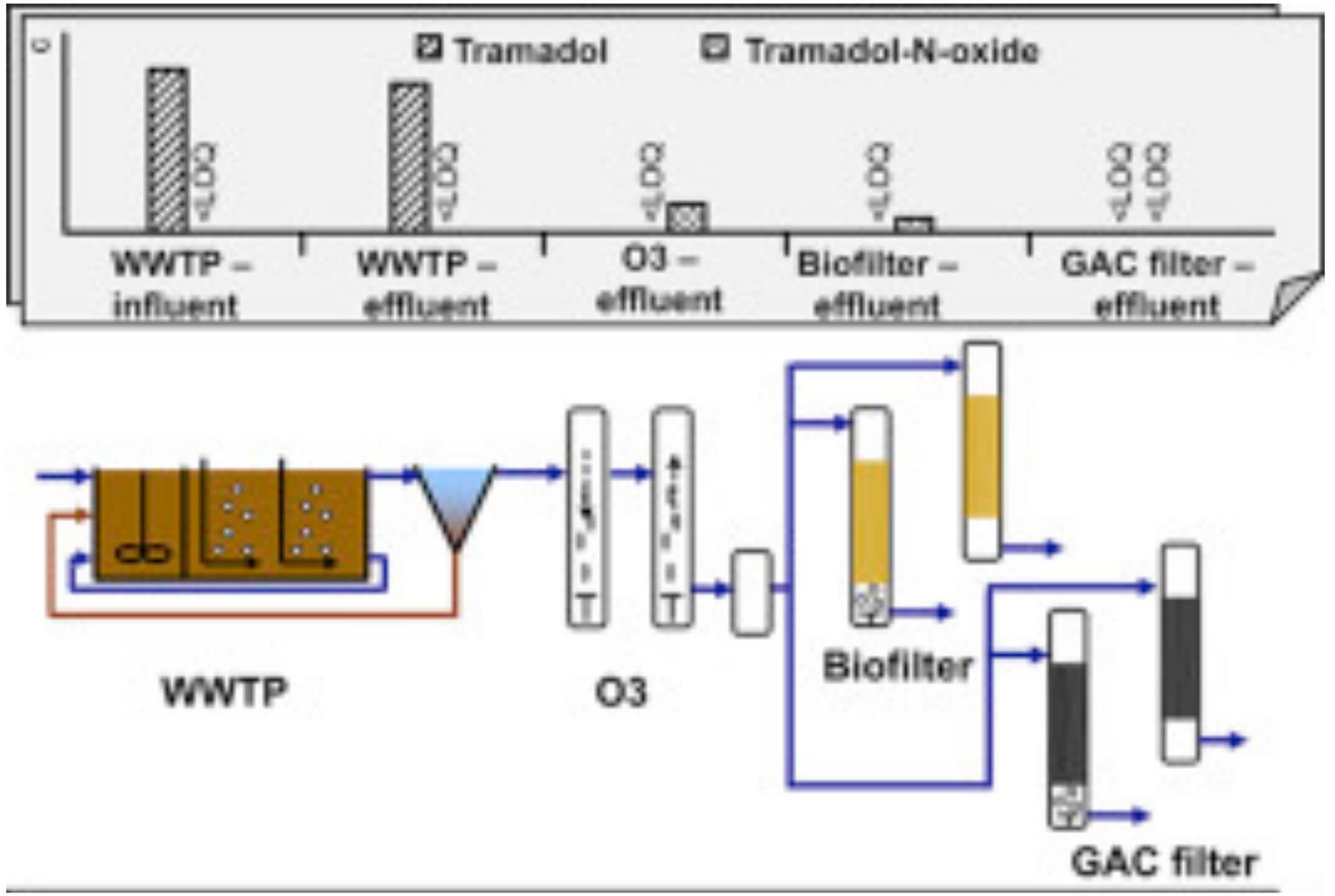
POST FILTRATION



Knopp, G., Prasse, C., Ternes, T. A., & Cornel, P. (2016). Elimination of micropollutants and transformation products from a wastewater treatment plant effluent through pilot scale ozonation followed by various activated carbon and biological filters. Water research, 100, 580-592.

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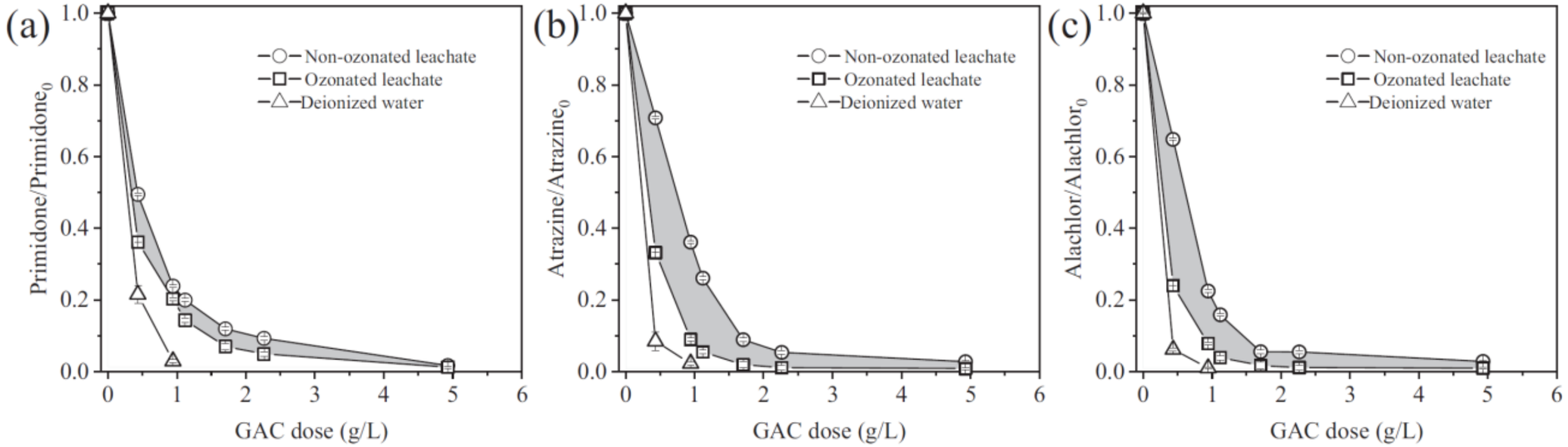
POST FILTRATION

– Combination improves removal

Y. Yang et al. Science of the Total Environment 820 (2022) 153349



Increased polarity, but less bulk organic material so less load to the activated carbon

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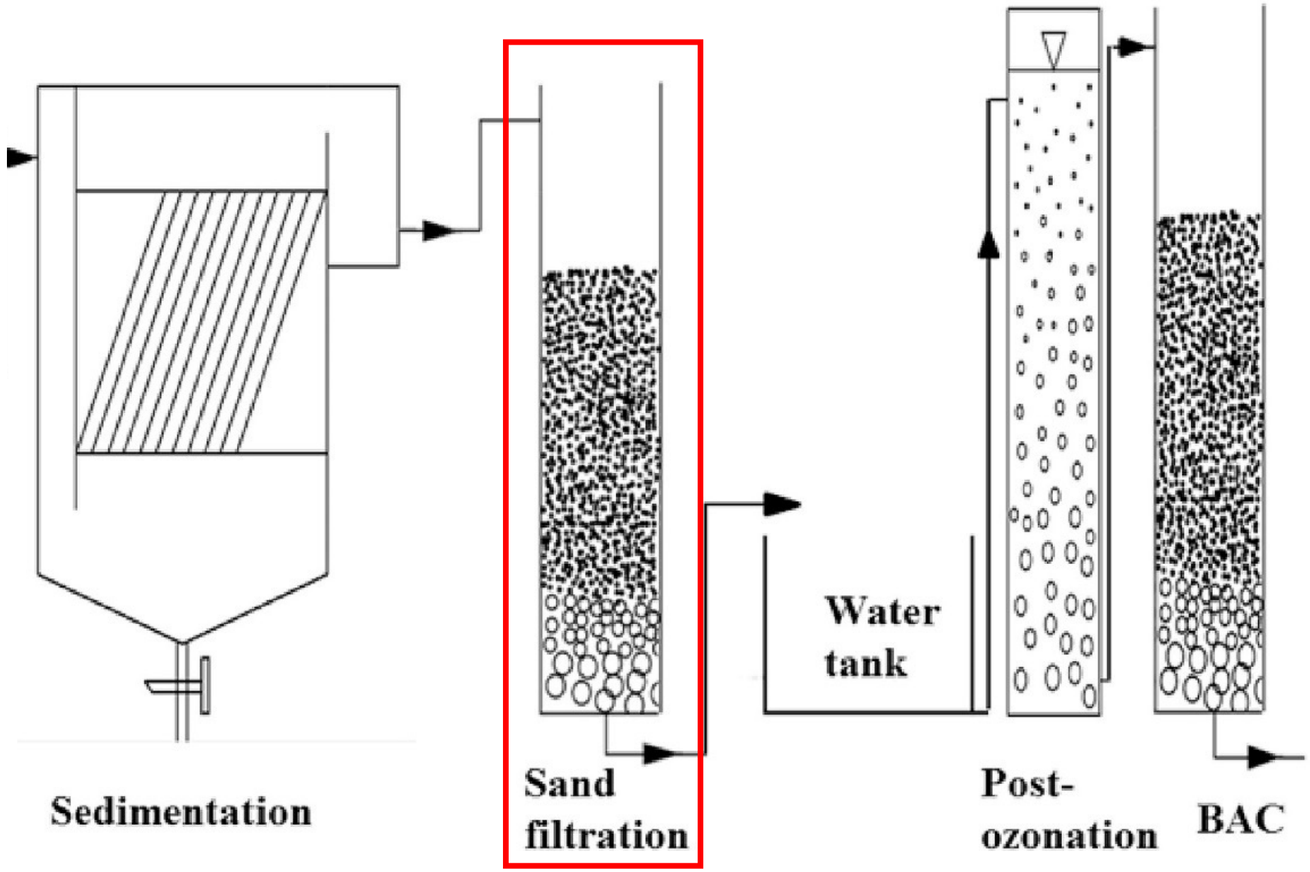
PREFILTRATION

- Remove (part) of the scavengers…
  - Sand, AIEX or AC



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PRE-FILTRATION

– Remove (part) of the scavengers…

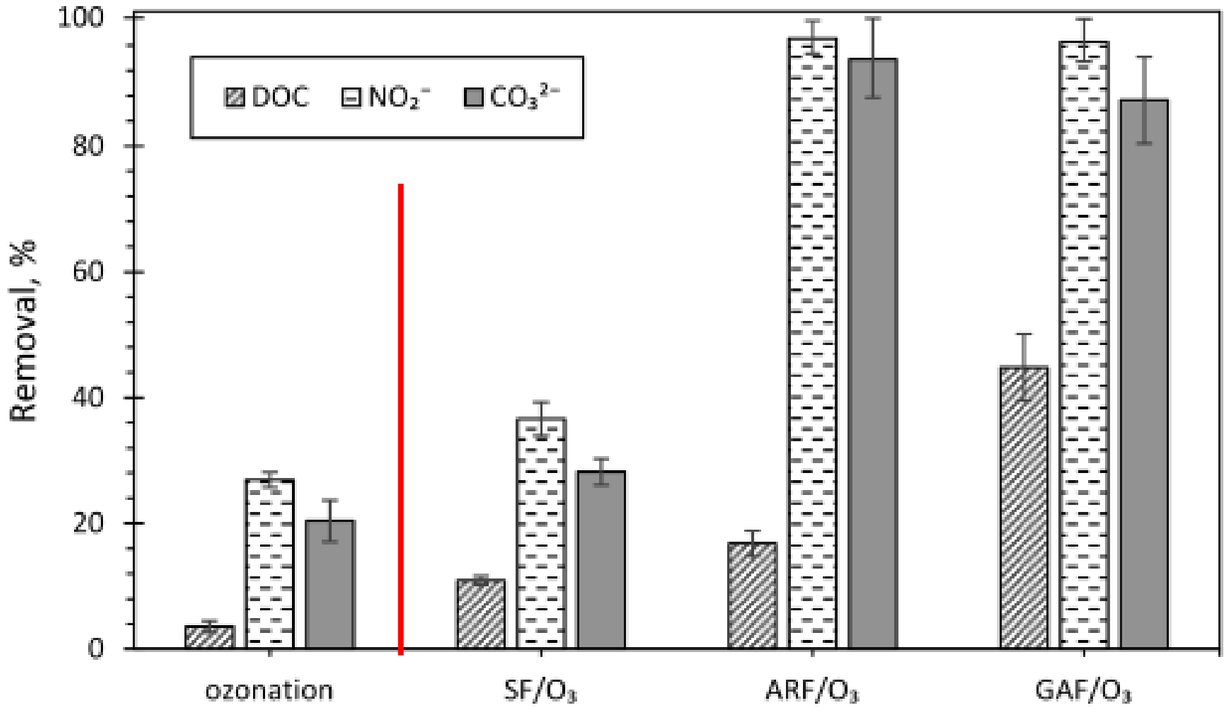

Figure 2. Removal of DOC, NO_2^-, and CO_3^{2-} via ozonation and combined filtration–ozonation (O_3 dose = 0.1 g O_3/g DOC).

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PRE-FILTRATION

– …increases µP removal -> less O_3 dose required

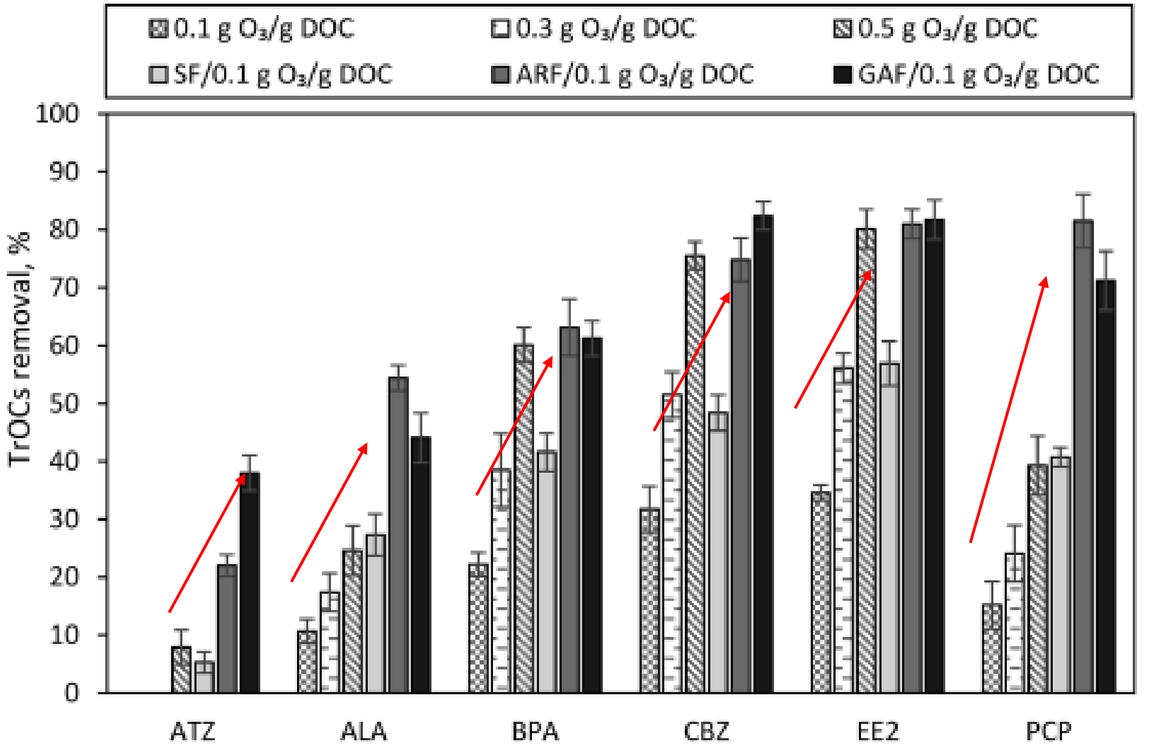

Figure 3. Elimination of TrOCs in effluent after ozonation and combined filtration–ozonation at different ozone doses.

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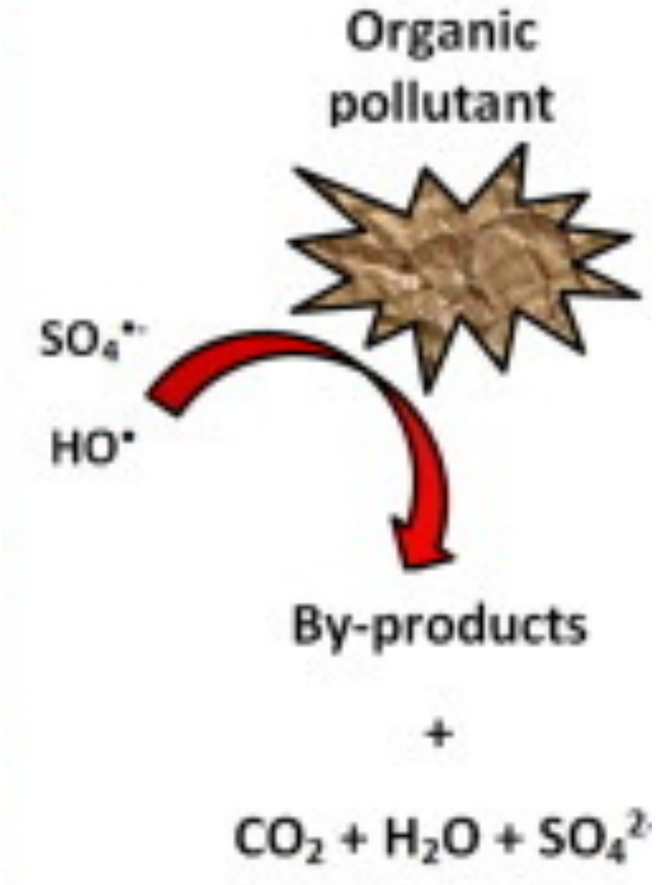
ADDITIONAL OXIDANTS

– E.g. PMS

O_3



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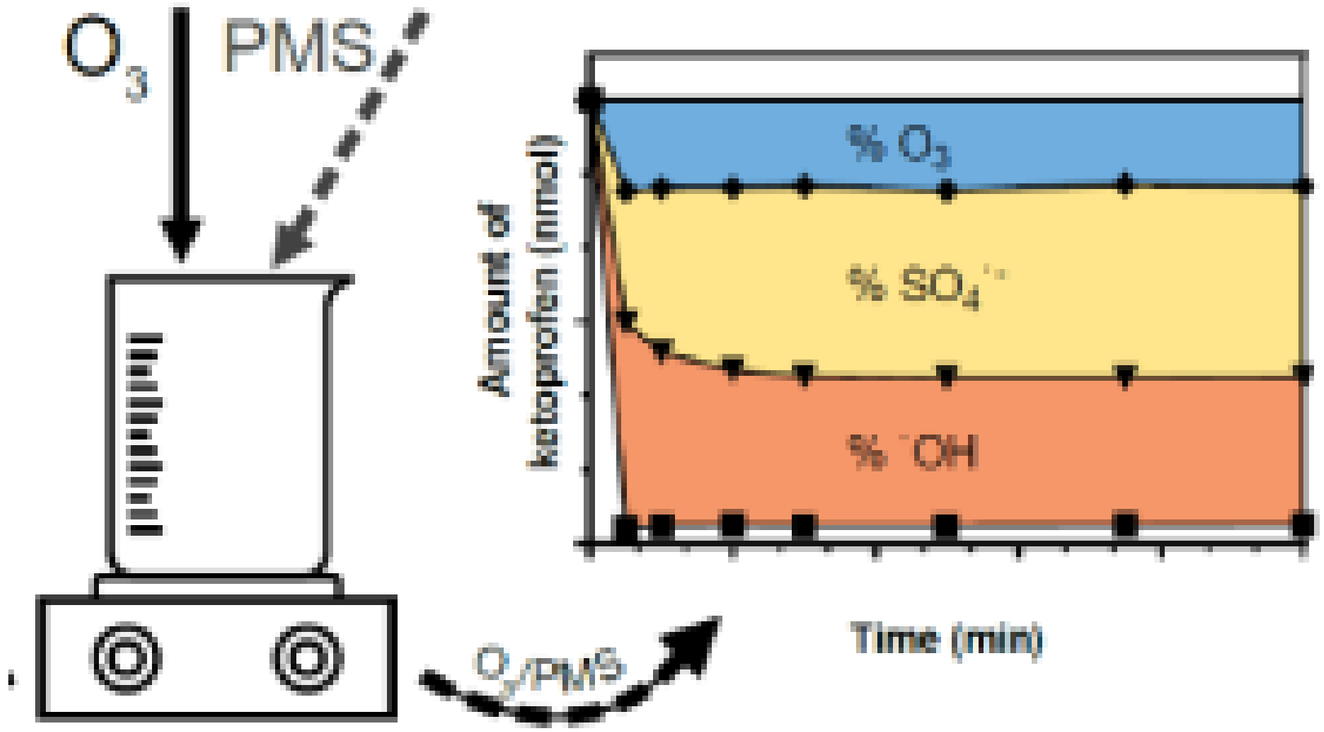
ADDITIONAL OXIDANTS

- E.g. PMS
  - Activation with O_3 -> 3 different oxidants (<-> 2)



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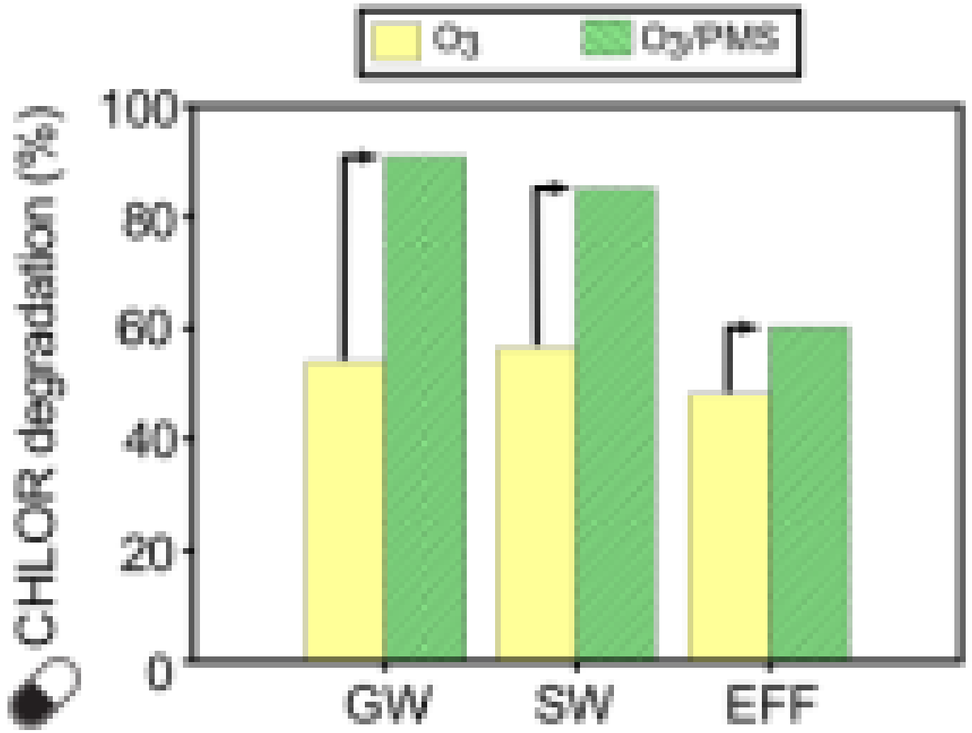
ADDITIONAL OXIDANTS

- E.g. PMS
  - Activation with O_3
    - Improved removal, especially in diluted matrix



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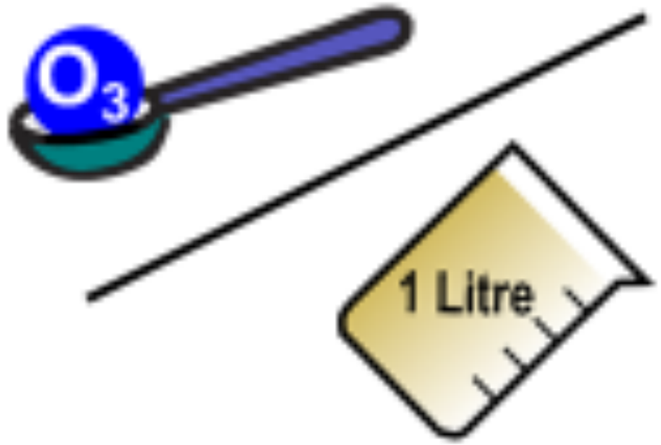
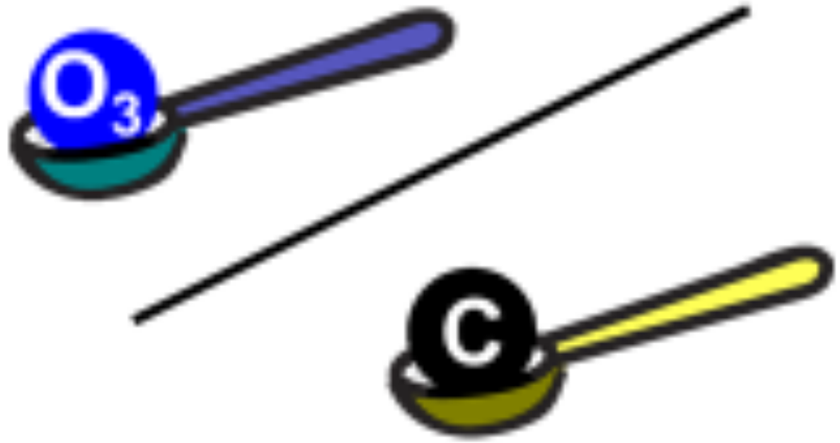
DOSING OPTIMISATION

- Classic
  - Flow based
  - Load based





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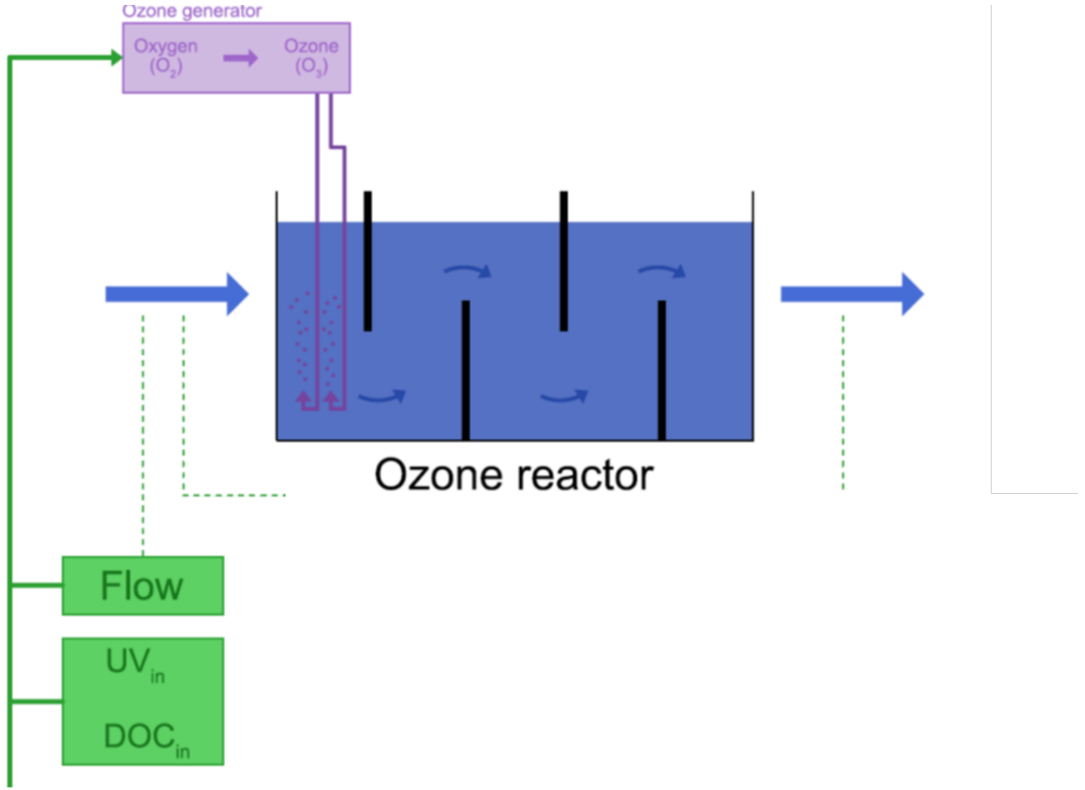
DOSING OPTIMISATION

- Classic
  - Flow based
  - Load based



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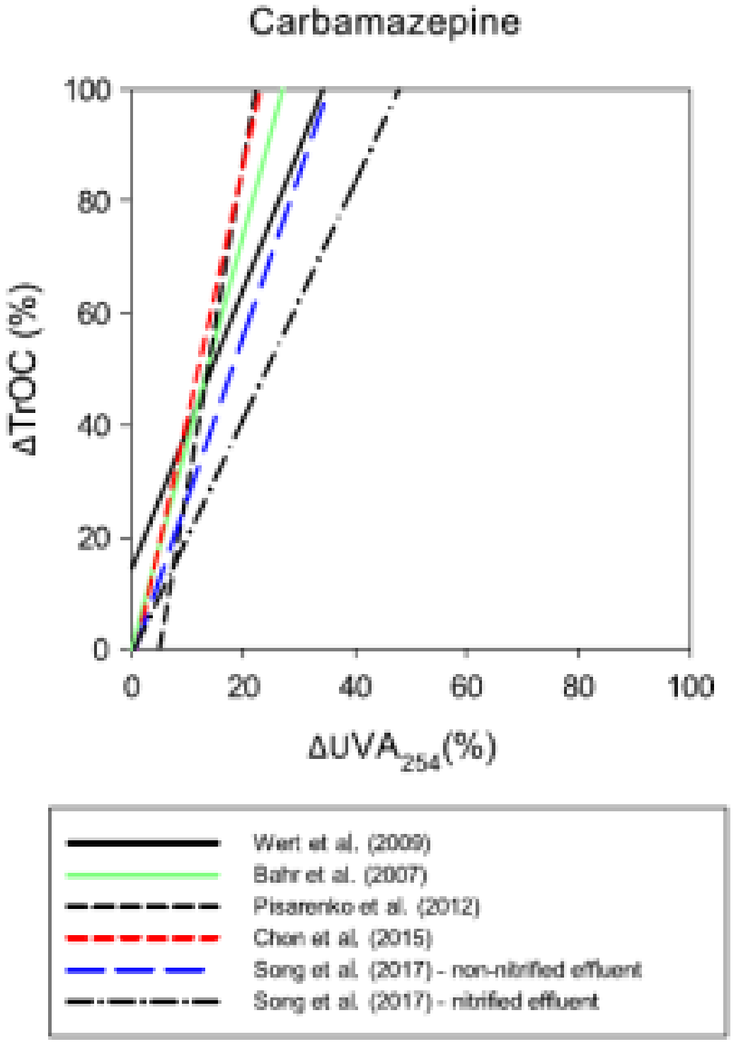
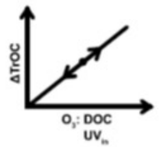
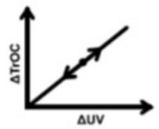
DOSING OPTIMISATION

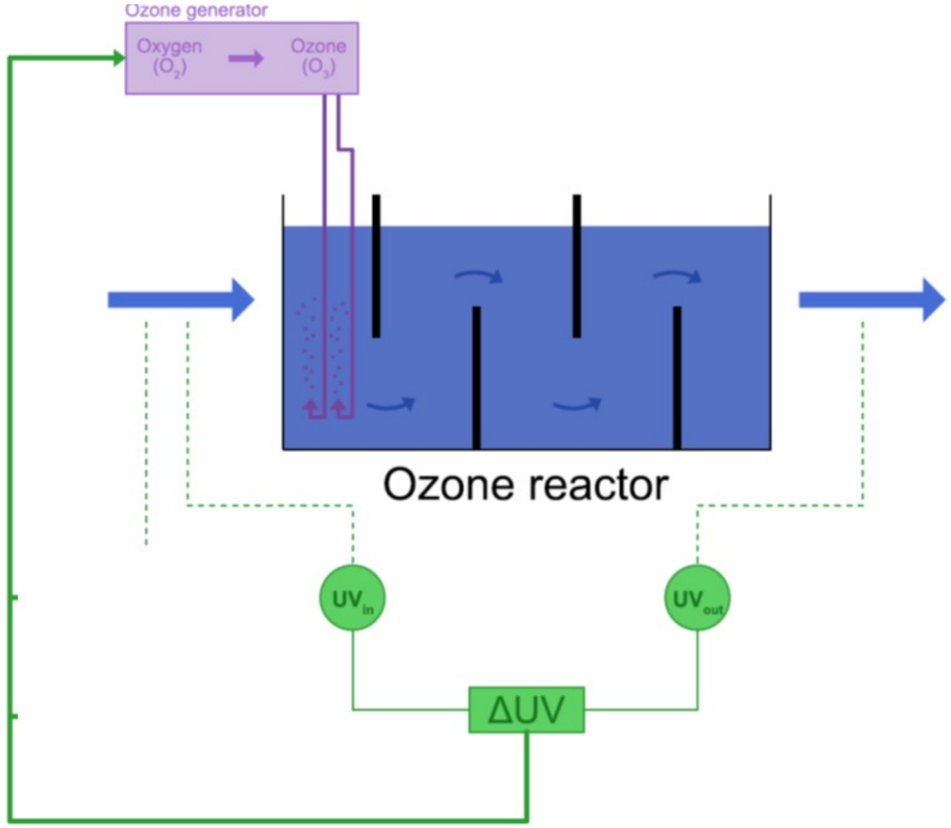
– Control based on ΔUV_{254}



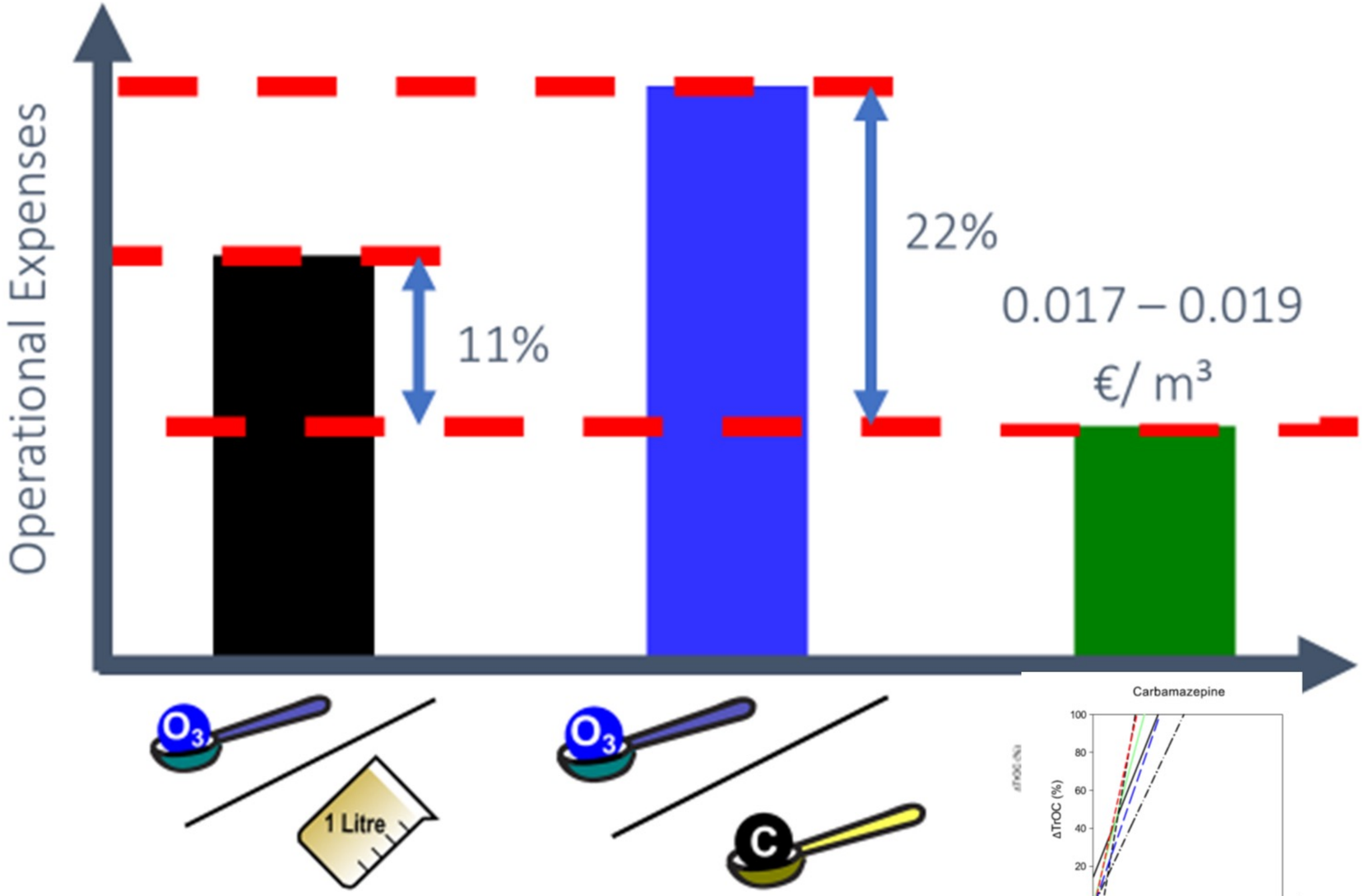
Models:







DOSING OPTIMISATION



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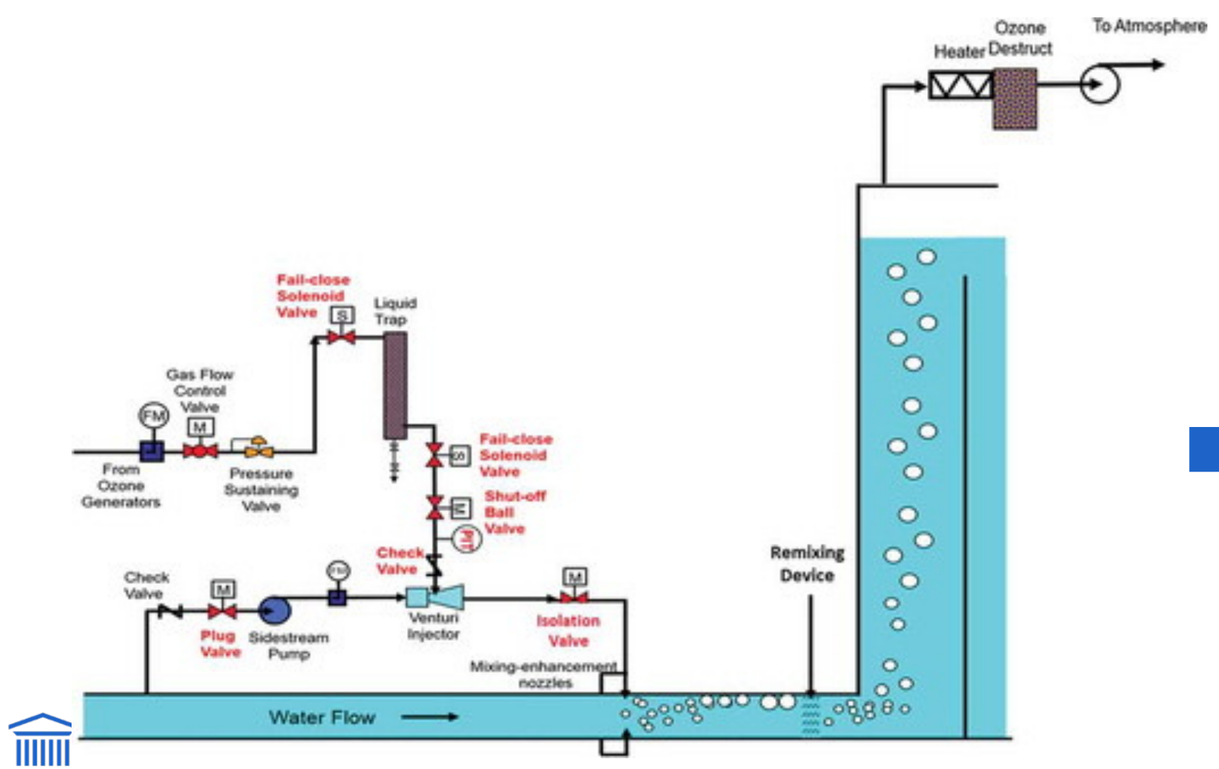
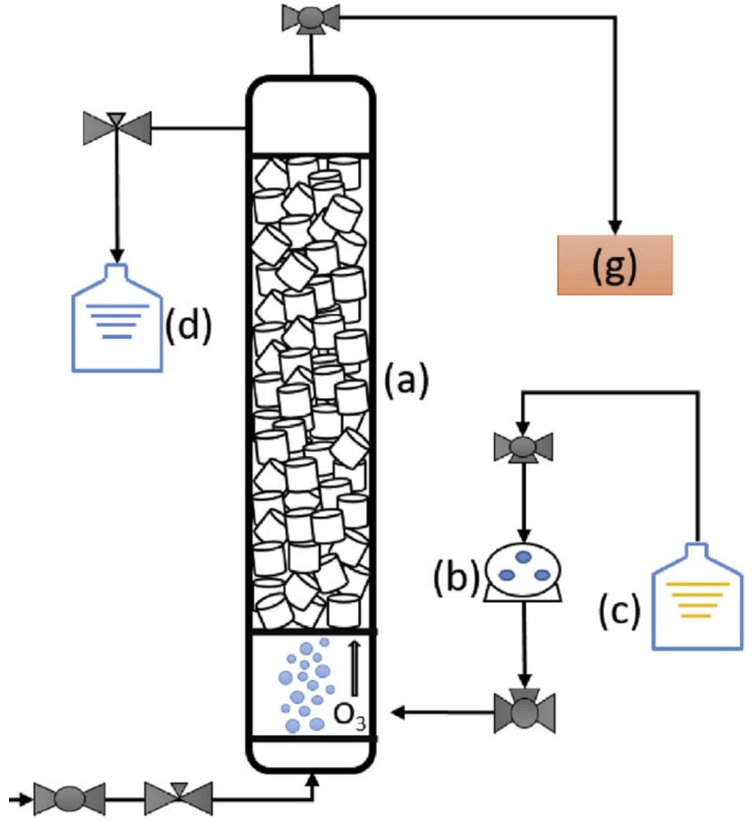
DOSING OPTIMISATION

– Packing material: better mass transfer/removal





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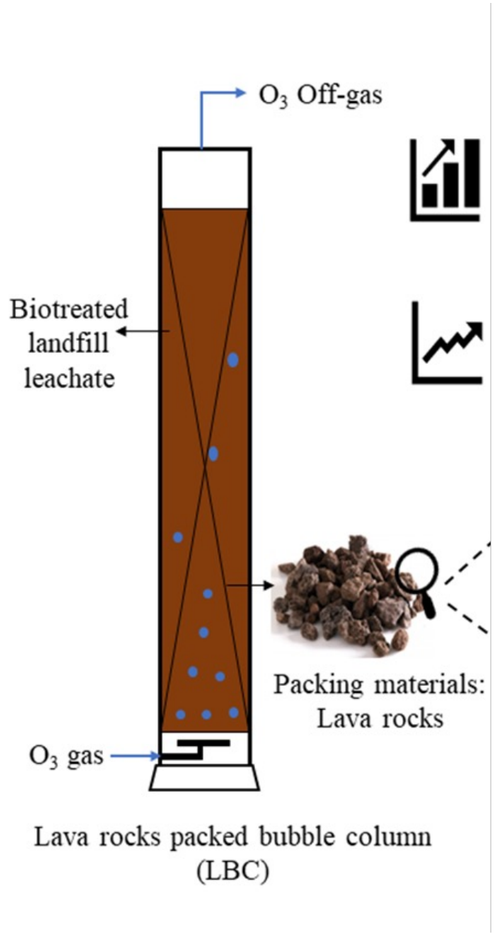
DOSING OPTIMISATION

– Packing material: better mass transfer/removal



Lava rocks packed bubble column (LBC)

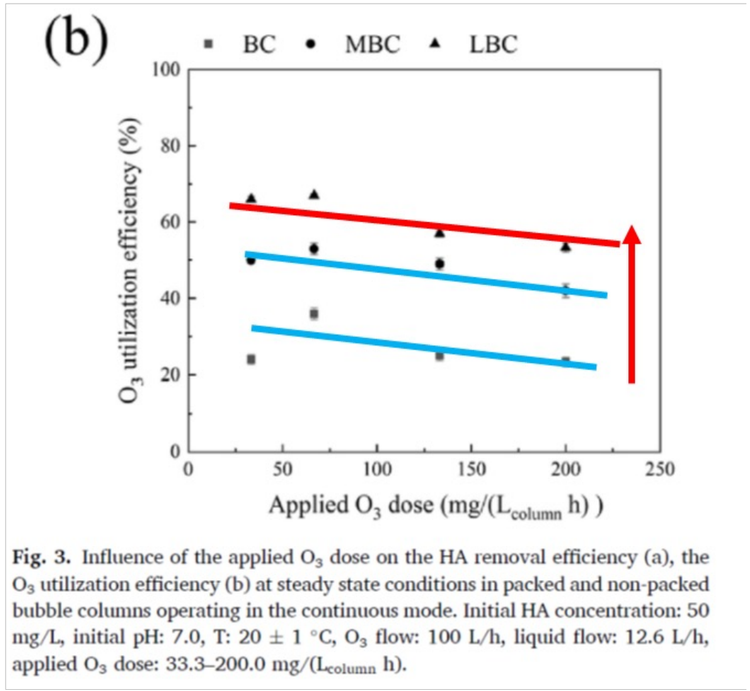


Fig. 3. Influence of the applied O_3 dose on the HA removal efficiency (a), the O_3 utilization efficiency (b) at steady state conditions in packed and non-packed bubble columns operating in the continuous mode. Initial HA concentration: 50 mg/L, initial pH: 7.0, T: 20 ± 1 °C, O_3 flow: 100 L/h, liquid flow: 12.6 L/h, applied O_3 dose: 33.3–200.0 mg/(L_{column} h).

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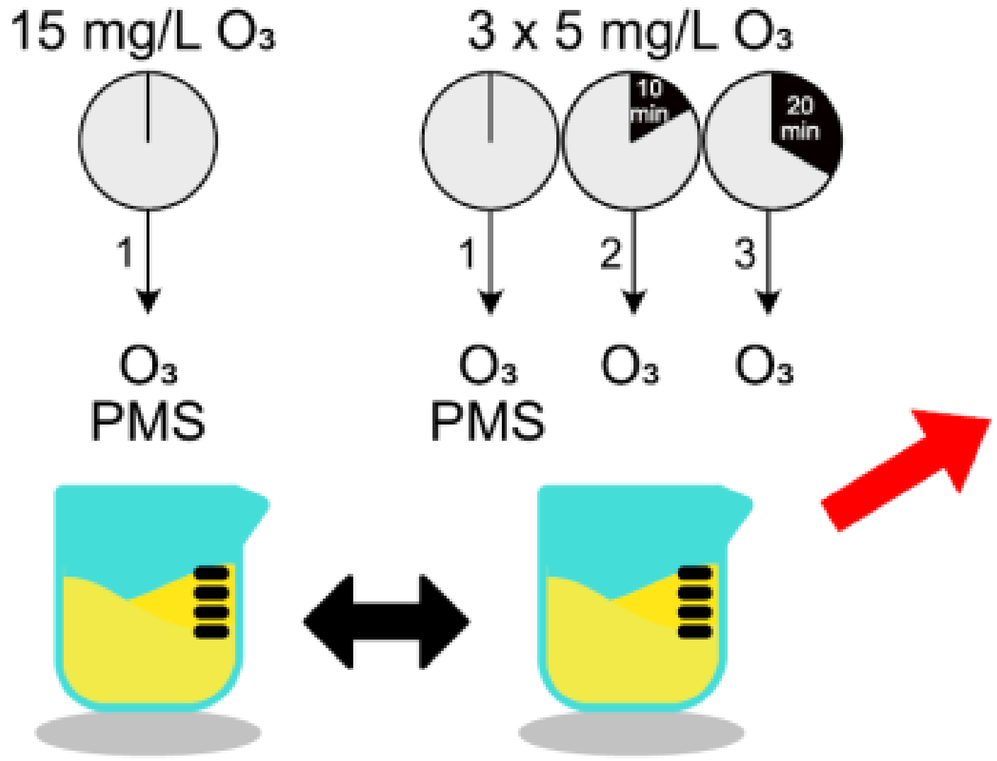
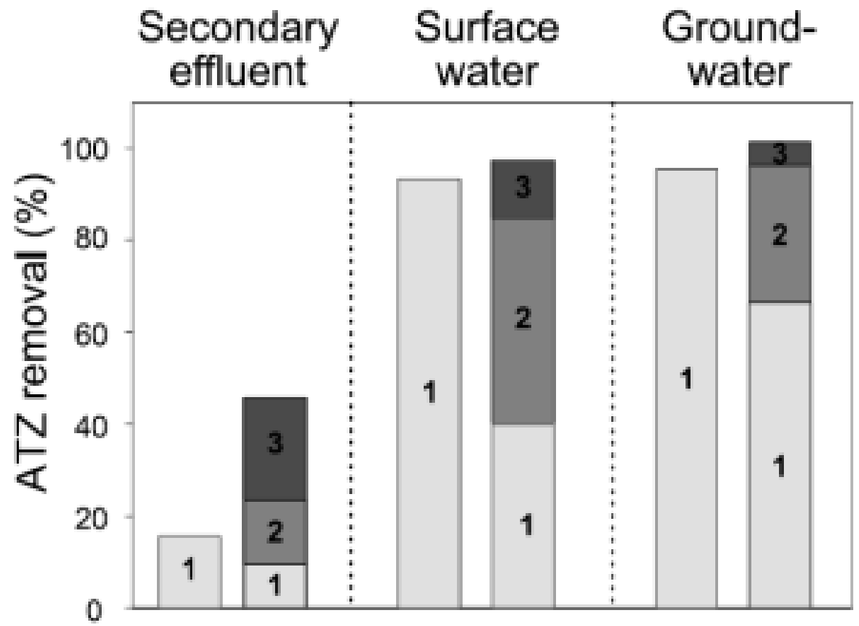
DOSING OPTIMISATION

– Multiple additions (plug flow)





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QUESTIONS?

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