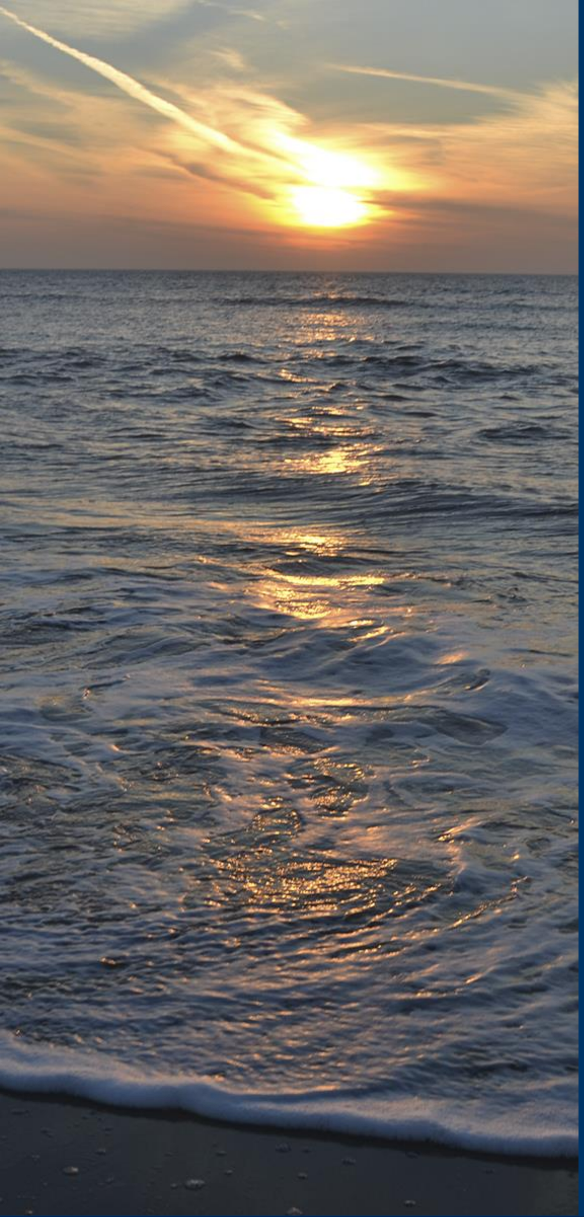

Optimization of IEX resin regeneration in a zero liquid discharge drinking water treatment plant

Klaas Schoutteten

De Watergroep / Ghent University / KWR

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De Watergroep

- Drinking water utility in Flanders, Belgium
- 3 million domestic customers
- 163 million m³ drinking water
- 72% groundwater, 28% surface water

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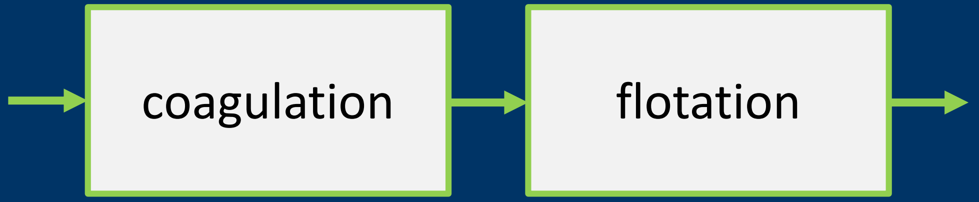
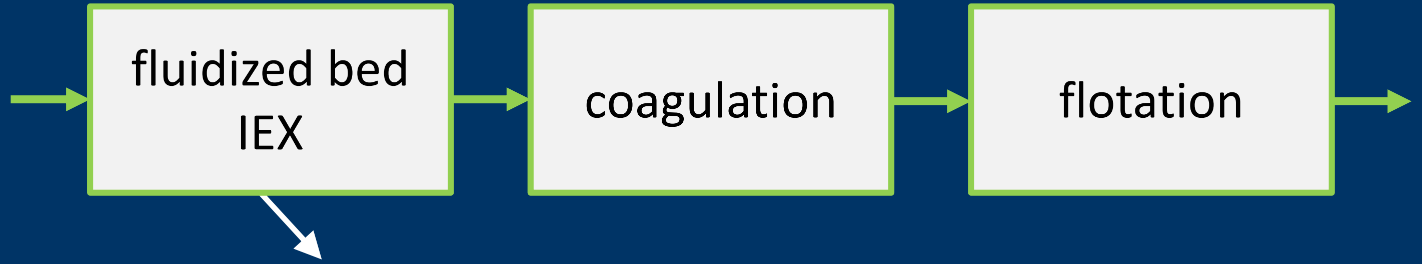
Combining IEX and coagulation for NOM removal

Current treatment:



New treatment (pilot plant):



- Reducing coagulant dose
- Improving overall NOM removal

IEX + coagulation pilots at 2 WTWs

WTW Kluizen (Evergem)

60 000 m³/d

DOC: 10 mg/L

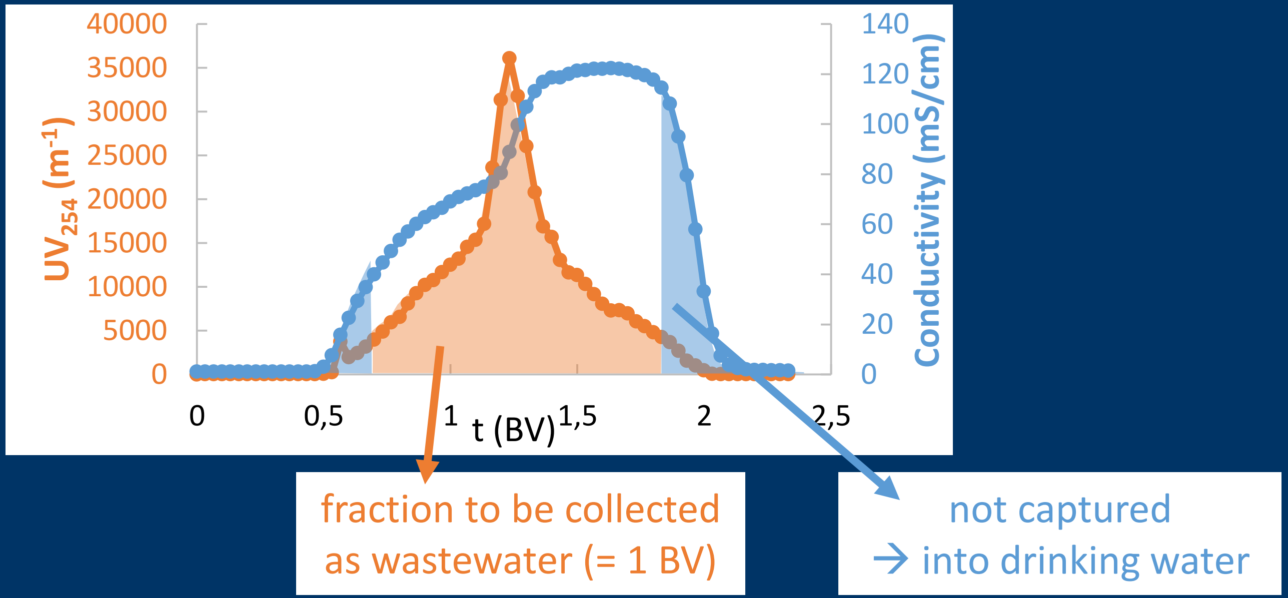
WTW De Blankaart (Diksmuide)

40 000 m³/d

DOC: 13 mg/L

Important site-specific consideration

- **No liquid discharge!**
  - → spent brine (high in organics and salts) must be treated on-site
    - → coagulation of organics
      - → solution is topped up with extra NaCl and reused as brine
- 1 BV brine = max. 1 BV of spent brine
  - → Everything eluting outside of the ‘collected spent brine BV’ → into drinking water



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regeneration frequency	NOM removal	Cl^- loss into drinking water
high		
low		

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How important is Cl^- loss?

- Drinking water limit: 250 mg/L Cl^-

- Sources of Cl^-:
  - Ion exchange (SO_4^{2-}, NOM, … → Cl^-)
  - Not-collected eluent
    - Front broadening during resin regeneration (advection, dispersion, diffusion, …)
    - Resin swelling after regeneration
  - Coagulation in drinking water ($FeCl_3$)

- Average Cl^- content in feed water:
  - WTW Kluizen: 48 mg/L Cl^-, sometimes higher
  - WTW De Blankaart: 121 mg/L Cl^-, sometimes higher + higher regeneration frequency

    ↳ Cl^- loss important!

Cl^- loss, what can we do?

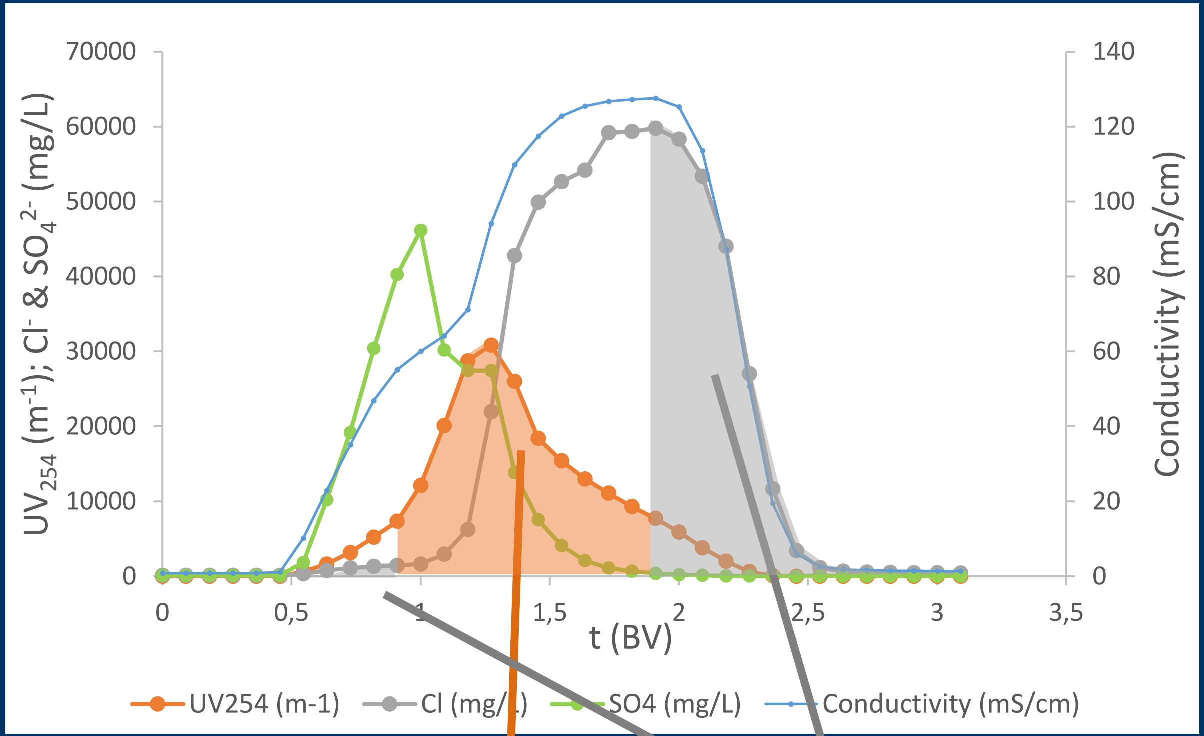
- Improve regeneration efficiency → reduce regeneration frequency

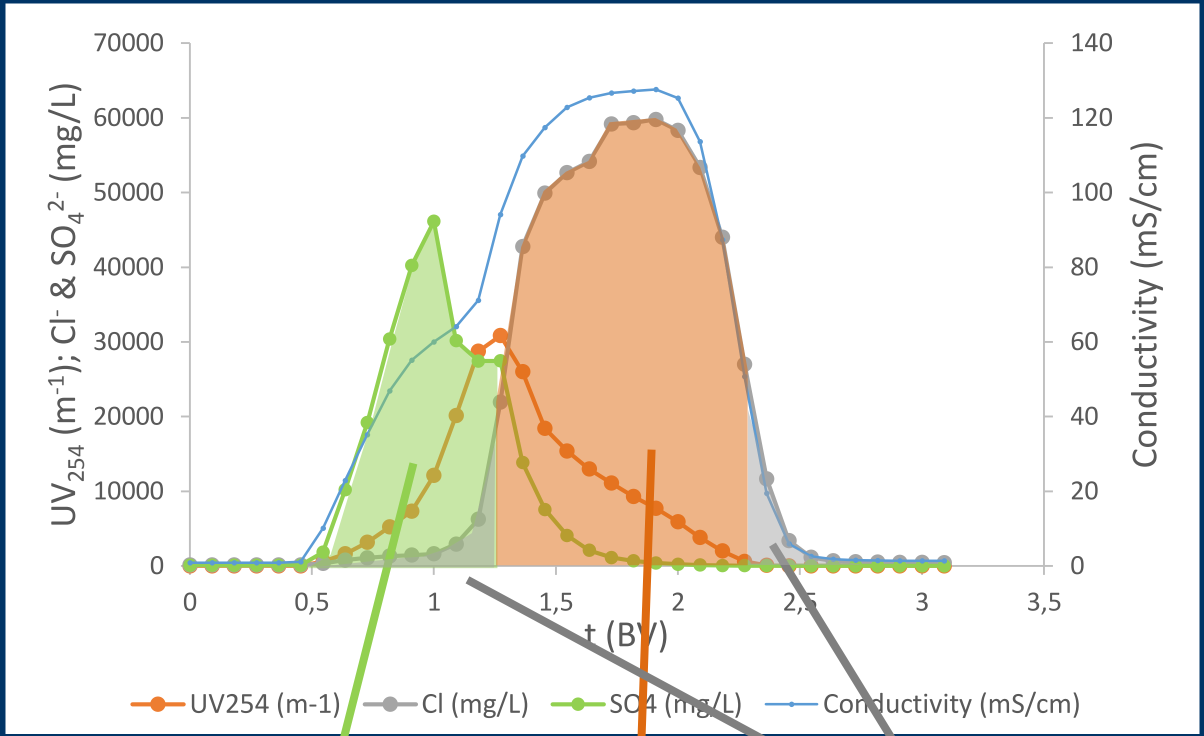
- Adapt spent brine collection

Improving regeneration efficiency

- Dosing method (slow trickling vs intermittent pumping) → slow trickling
- CT (10’ vs 30’ vs 60’) → min. 30’
- H/D (2 vs 4 vs 6 vs 9) → acceptable from 4 on
- NaCl concentration (5% vs 7,5% vs 10%) → 10%
- Alkaline regeneration (10% NaCl vs 10% NaCl + 2% NaOH) → alkaline: 26% more NOM desorbed

Adapting spent brine collection: ion elution profiles





1 BV spent brine
→ coagulation
→ brine

Cl^- loss
→ drinking water
(35,1 g)

SO_4^{2-} rich fraction
→ coagulation
→ drinking water

1 BV spent brine
→ coagulation
→ brine

Cl^- loss
→ drinking water
(12,5 g)

Composition of two spent brine fractions

	1st fraction	2nd fraction
Volume	0,82 BV	1 BV
UV_{254}	42%	58%
SO_4^{2-}	83%	17%
Cl^-	5%	95%

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Advantages of collecting two spent brine fractions

- Nearly all NOM removed with IEX is processed through spent brine coagulation
- SO_4^{2-}-rich fraction: coagulation with $Fe_2(SO_4)_3$ instead of $FeCl_3$
- In a later stage: perhaps also SO_4^{2-} removal from SO_4^{2-}-rich fraction
- Less NaCl needed to top up spent brine
- Less SO_4^{2-} accumulation in collected and recirculated spent brine

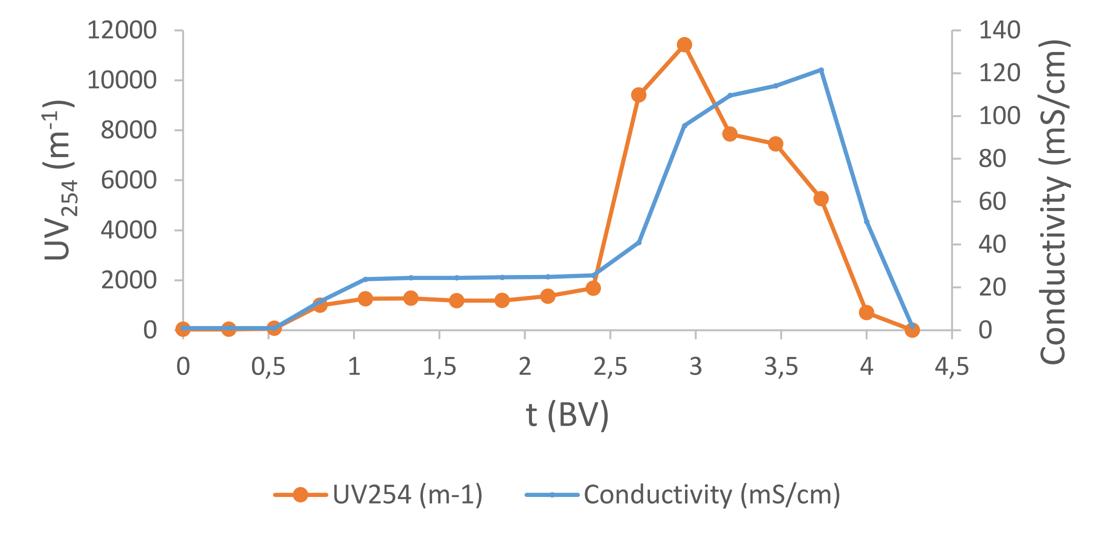
One step further: stepwise regeneration

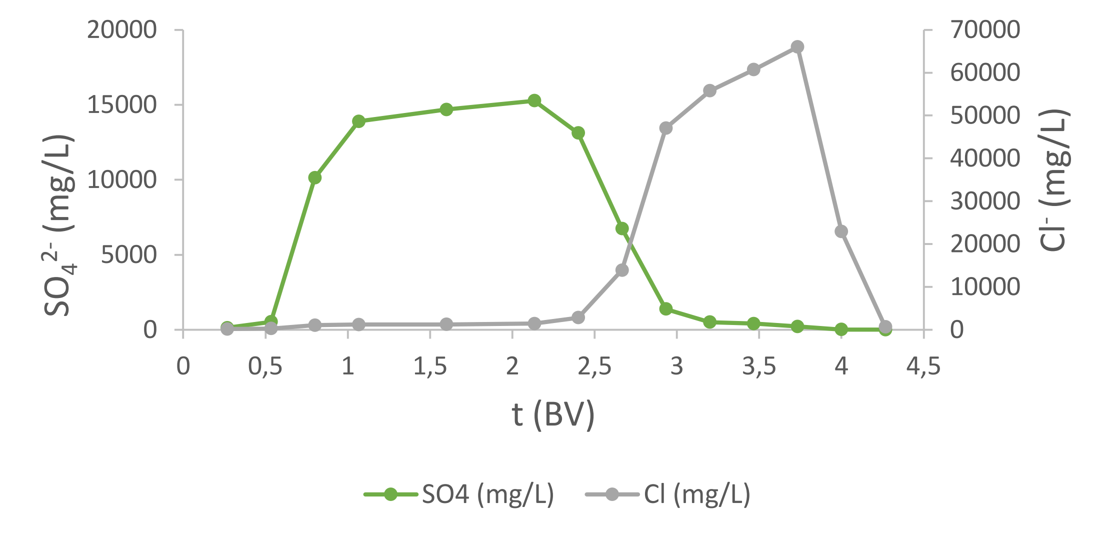
Objective: separate desorption of SO_4^{2-} and NOM

- Regeneration with:
  - 2 BV of 2% NaCl → will SO_4^{2-} fraction still require NOM removal?
  - 1 BV of 10% NaCl
- Additional advantage: 2% NaCl can be made by diluting 10% NaCl brine

  → ± 1,4 BV of spent brine can be collected

Stepwise regeneration





	1st fraction	2nd fraction
Volume	2,4 BV	1,4 BV
UV_{254}	27%	73%
SO_4^{2-}	94%	6%
Cl^-	6%	94%

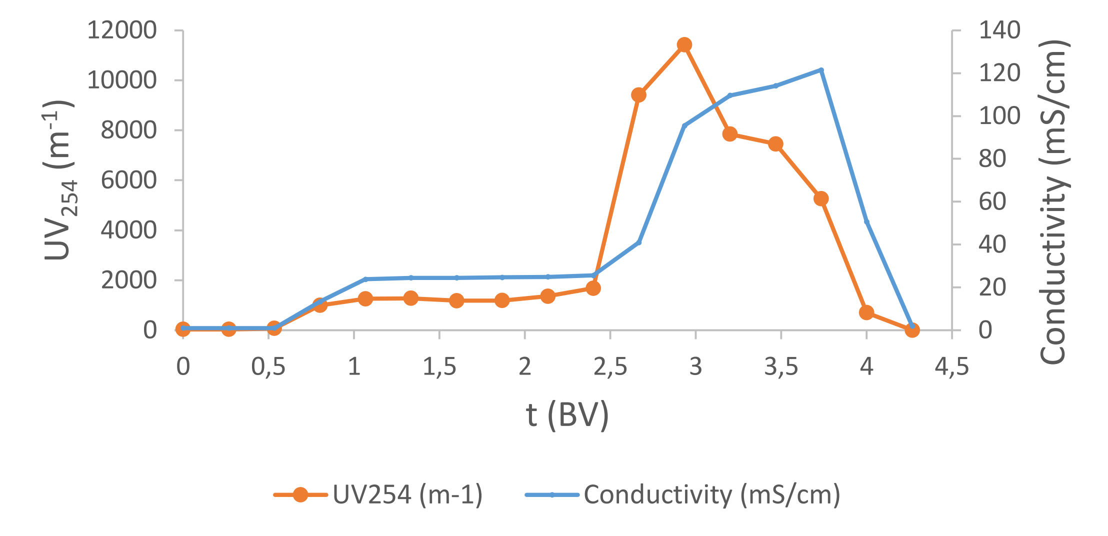
- Much better SO_4^{2-} separation

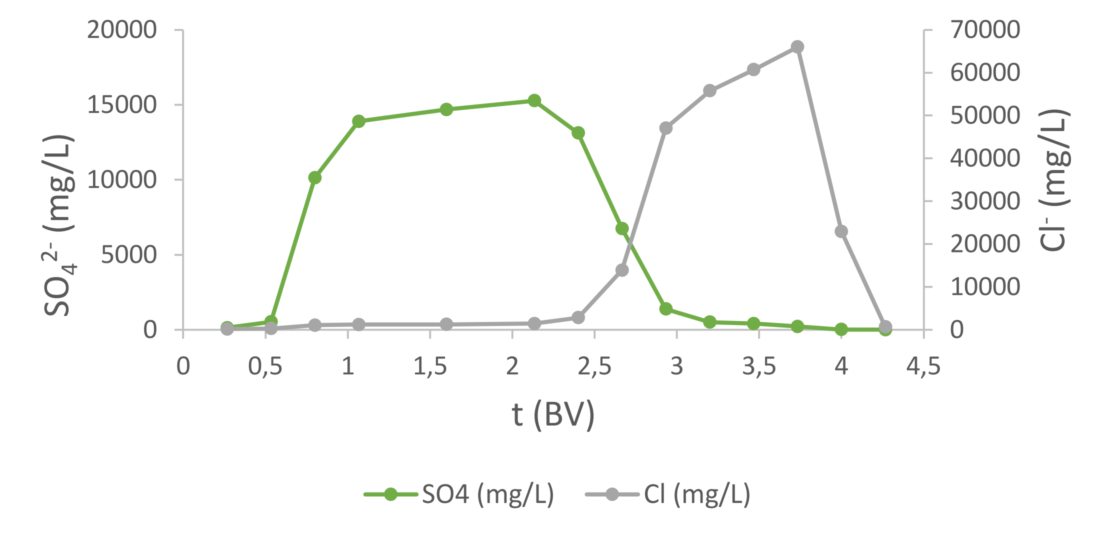
But…

- Still too much NOM in 1st fraction
- Too much Cl^- in 1st fraction (14 g)

  (not compensated by extra 0,4 BV collected)

Stepwise regeneration





Origin of Cl^- in 1st fraction:

- Co-eluting Cl^- with SO_4^{2-}: 1300 mg Cl^-/L
- Much less loaded resin during 10% NaCl passage = more front broadening

Origin of NOM in 1st fraction:

- Co-eluting NOM with SO_4^{2-}: 1200 m^{-1}
- In transition zone 2% - 10% NaCl

→ In ZLD locations where Cl^- loss should be minimized: single-step regeneration > stepwise regeneration

A special word of thanks:

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