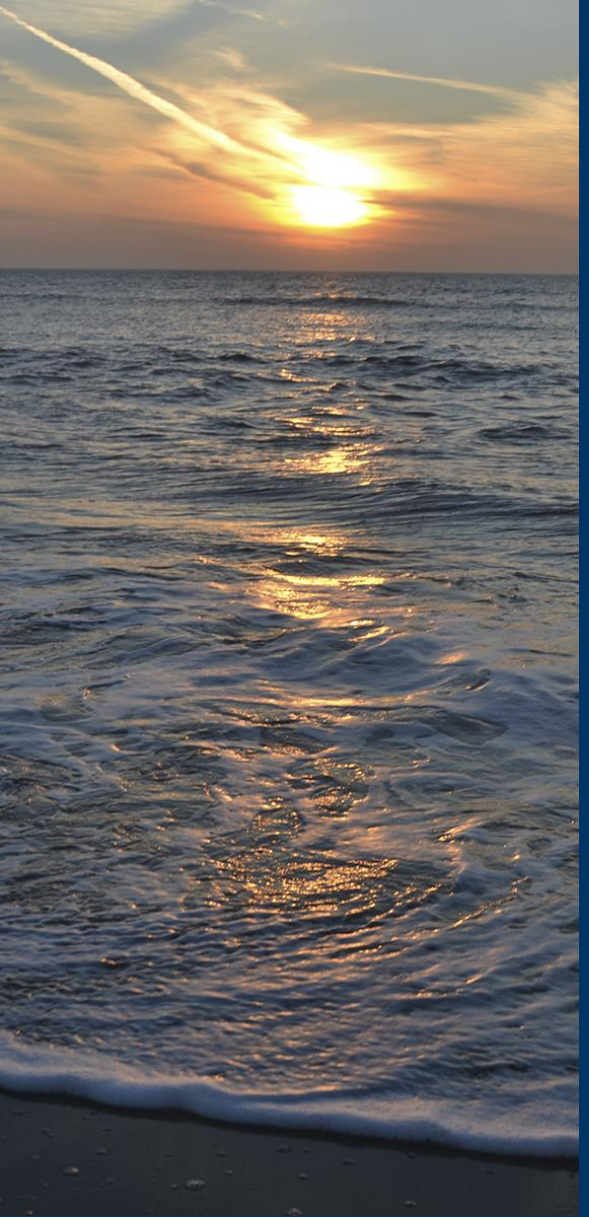

DOC removal by fluidized ion exchange and coagulation-flotation

Liesbeth Verdickt

De Watergroep

21 September 2016

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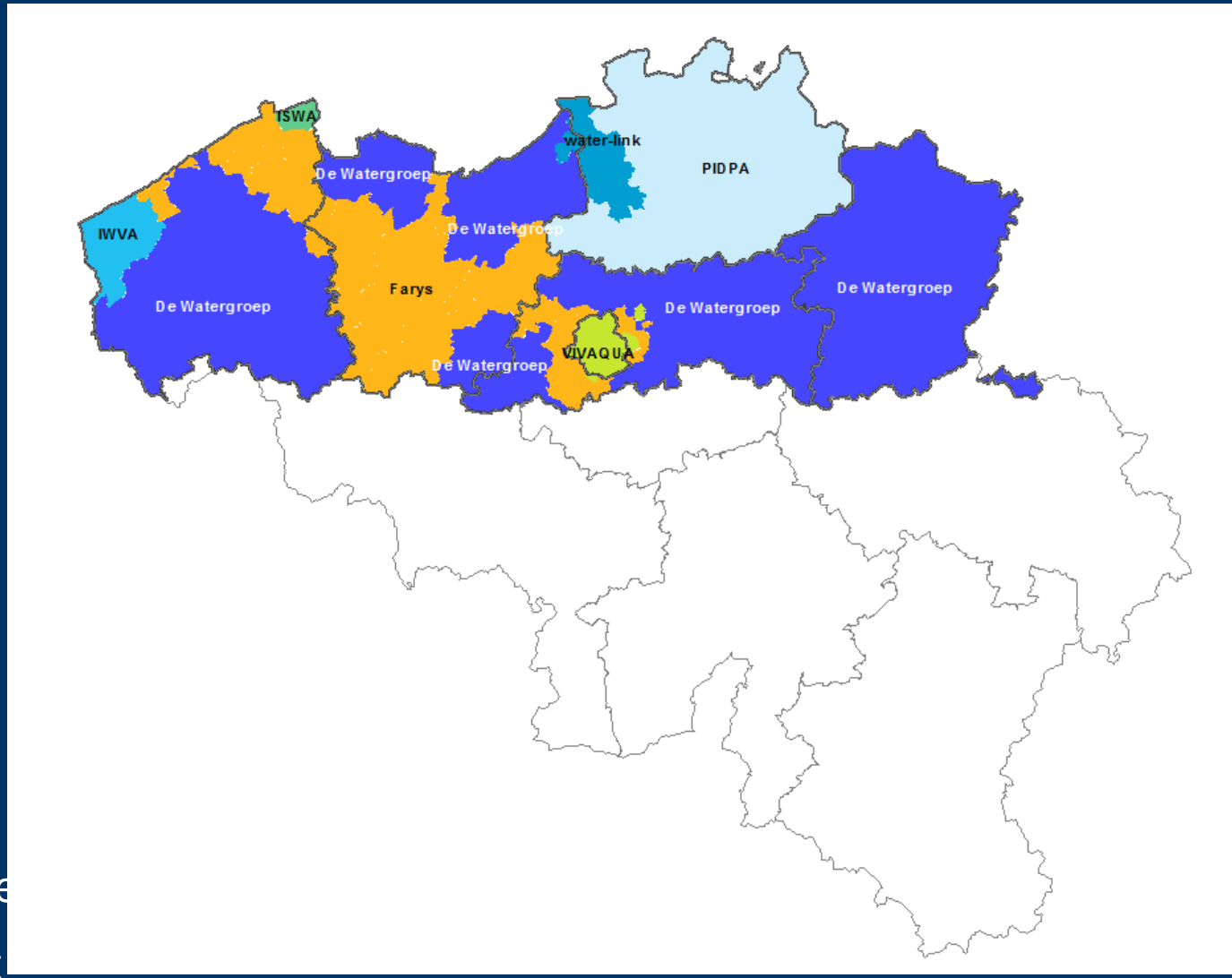
De Watergroep

Public drinking water company

- Largest water company in the Flanders
- Our customers
  - 175 municipalities
  - 1.3 million connections
  - 3 million domestic customers
  - Growing markets for
    - Industrial water treatment
    - Engineering services in the water cycle
    - Waste water collection and treatment



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De Watergroep

Infrastructure for production

- Yearly production ≈ 120 million m³
  - 71% ground water
  - 29% surface water
- Production plants & water abstractions
  - Ground water abstractions 85

    ⇒ Water treated in 64 production plants
  - Surface water abstractions 5

    ⇒ Water treated in 5 production plants

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Surface water treatment plants with elevated DOC levels

Kluizen

- Near Ghent, 60 000 m³/day
- In operation since 1974

Blankaart

- 20 km from the North Sea, 40 000 m³/day
- In operation since 1972

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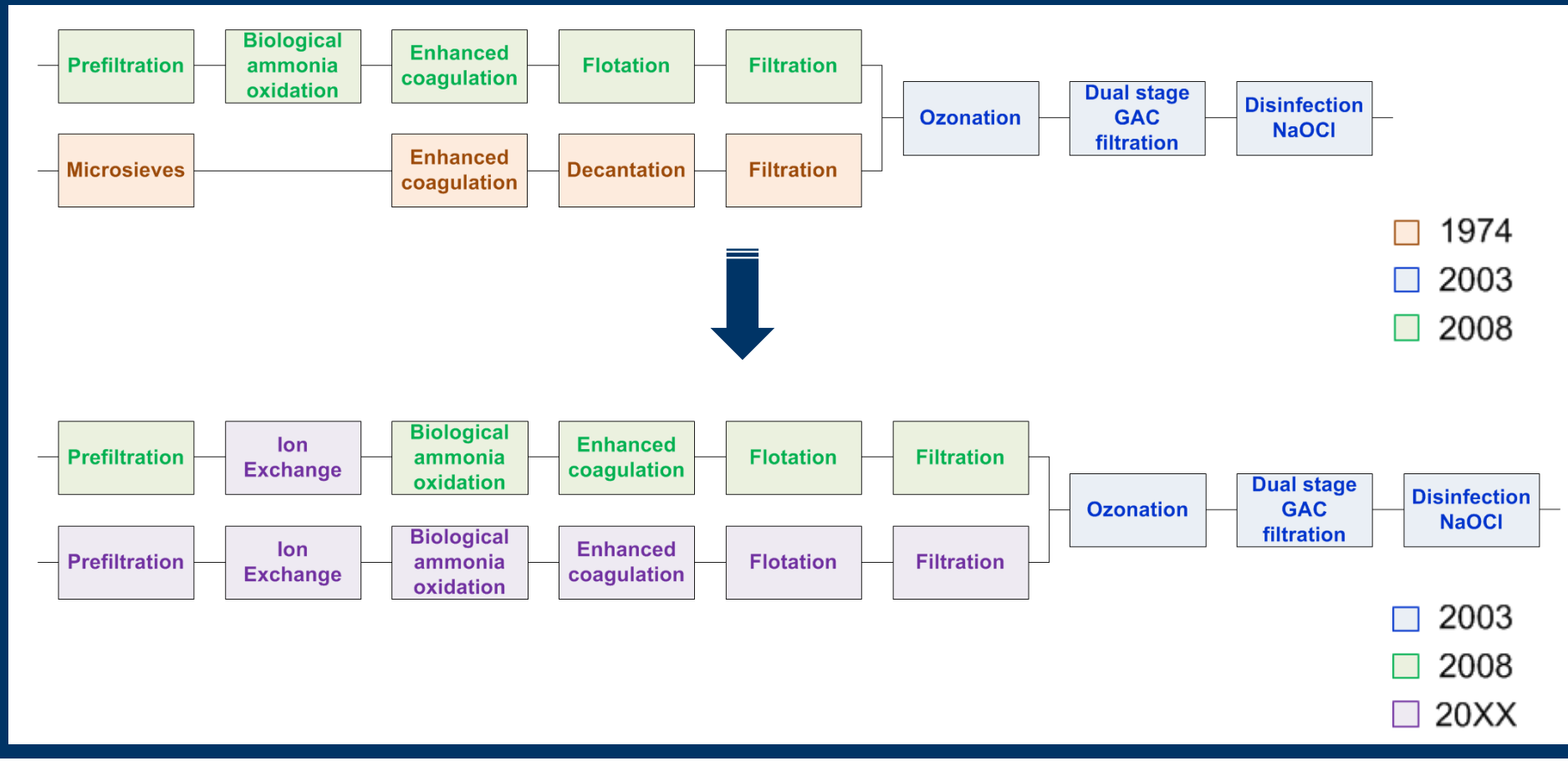
Surface water treatment plants with elevated DOC levels

Raw water quality

	Kluizen	Blankaart
NPOC (mg C/l)	9.8 (8.5 – 11.9)	12.0 (8.8 – 15.5)
UV_{254} (m^{-1})	24 (13 – 30)	22 (18 – 28)
SUVA	2.5 (1.5 – 3.0)	2.1 (1.5 – 2.6)
Conductivity (µS/cm)	615 (536 – 673)	799 (645 – 979)
Chloride (mg/l)	48 (43 – 51)	98 (66 – 141)
Sulfate (mg/l)	65 (55 – 76)	86 (76 – 98)
Turbidity (NTU)	1.5 (0.7 – 3.6)	3.4 (0.85 – 9.0)
Alkalinity (mmol/l)	4.3 (3.4 – 5.0)	4.0 (3.1 – 5.0)
pH (-)	7.3 – 8.6	8.0 – 8.9
Chlorofyl (µg/l)		25 (0.2 – 93)
Phosphate (mg/l)	0.26 (0.04 – 0.76)	0.72 (0.37 – 1.37)
NH_4^+ (mg/l)	0.23 (0.05 – 0.60)	0.48 (0.05 – 1.10)
Nitrate (mg/l)	7 (1 – 11)	10 (0 – 21)

Kluizen – treatment scheme



Blankaart – treatment scheme

Present

Prefiltration → Biological ammonia oxidation → Enhanced coagulation → Decantation → Filtration → GAC filtration → Disinfection NaOCl

2018

Prefiltration → Biological ammonia oxidation → Enhanced coagulation → Decantation → Filtration → Ozonation → Dual stage GAC filtration → Disinfection UV/NaOCl

2023

Prefiltration → Biological ammonia oxidation → Ion Exchange → Enhanced coagulation → Flotation → Filtration → Ozonation → Dual stage GAC filtration → Disinfection UV/NaOCl

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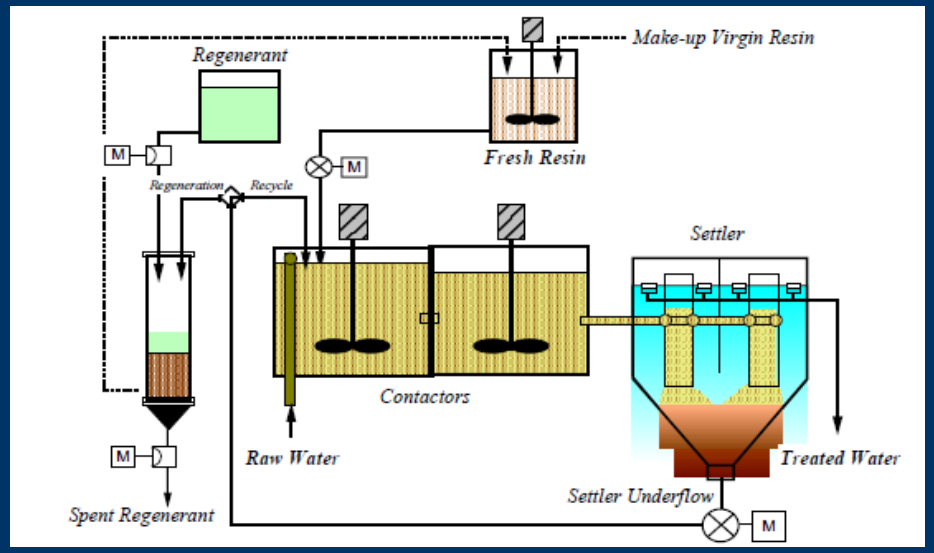
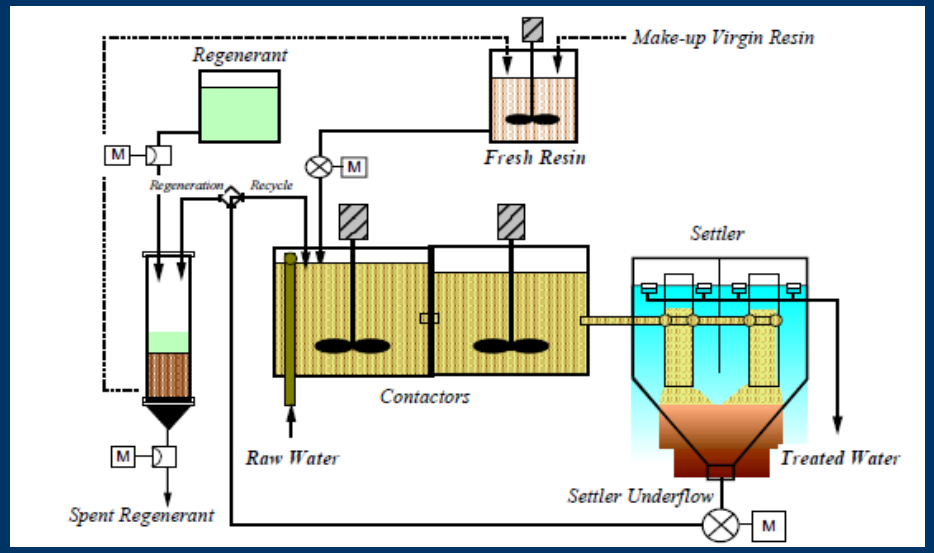
10 years of DOC research @ De Watergroep

- Kluizen 2005 – 2007: Miex® contactor-settler – ultrafiltration – ozonation – dual stage GAC filtration (50 m³/h)



10 years of DOC research @ De Watergroep

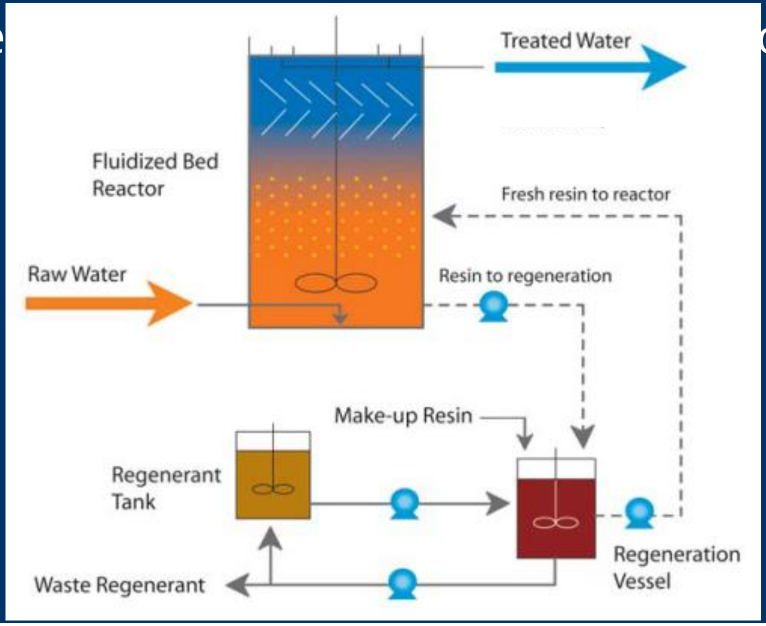
- Kluizen 2005 – 2007: Miex® contactor-settler – ultrafiltration – ozonation – dual stage GAC filtration (50 m³/h)



IEX
- ✓ DOC removal
- ✗ Miex® patented and expensive
  Foot print
  Resin manipulations

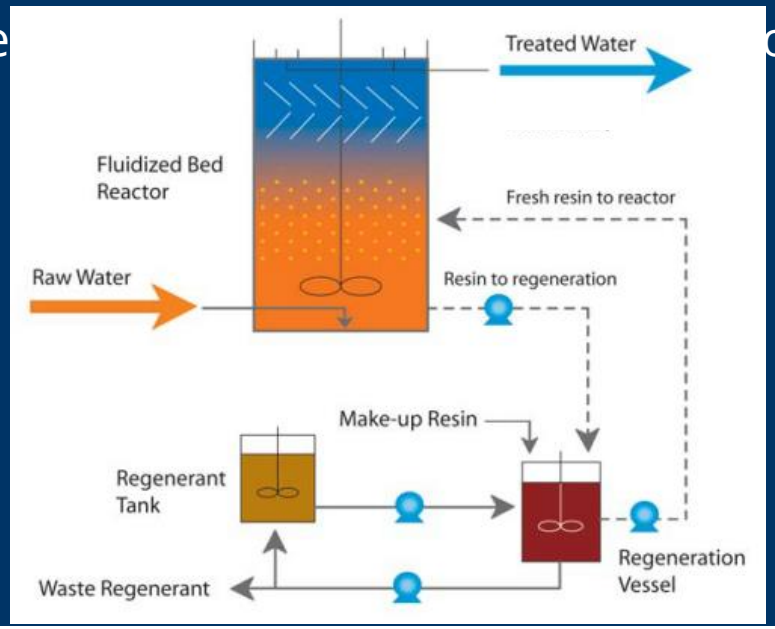
Ultrafiltration
- ✗ DOC removal
  Membrane fouling

10 years of DOC research @ De Watergroep

- Kluizen 2005 – 2007: Miex® contactor-settler – ultrafiltration – ozonation – dual stage GAC filtration (50 m³/h)
- Kluize  oagulation / flotation (25 m³/h)

10 years of DOC research @ De Watergroep

- Kluizen 2005 – 2007: Miex® contactor-settler – ultrafiltration – ozonation – dual stage GAC filtration (50 m³/h)
- Kluize[illegible]oagulation / flotation (25 m³/h)



IEX
- ✓ DOC removal
  Foot print
- ✗ Miex® patented and expensive
  Resin manipulations

Coagulation - flotation
- ✓ DOC removal
  Stable operation

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10 years of DOC research @ De Watergroep

- Kluizen 2005 – 2007: Miex® contactor-settler – ultrafiltration – ozonation – dual stage GAC filtration (50 m³/h)
- Kluizen 2011 – 2012: Miex® high rate – coagulation – flotation (25 m³/h)

- Kluizen 2012 – 2013: Fluidized bed IEX – coagulation – flotation (25 m³/h)
- Blankaart 2015 – present: Fluidized bed IEX – coagulation – flotation (50 m³/h)

IEX

✓ DOC removal
Foot print
Resin manipulations
Conventional IEX resin

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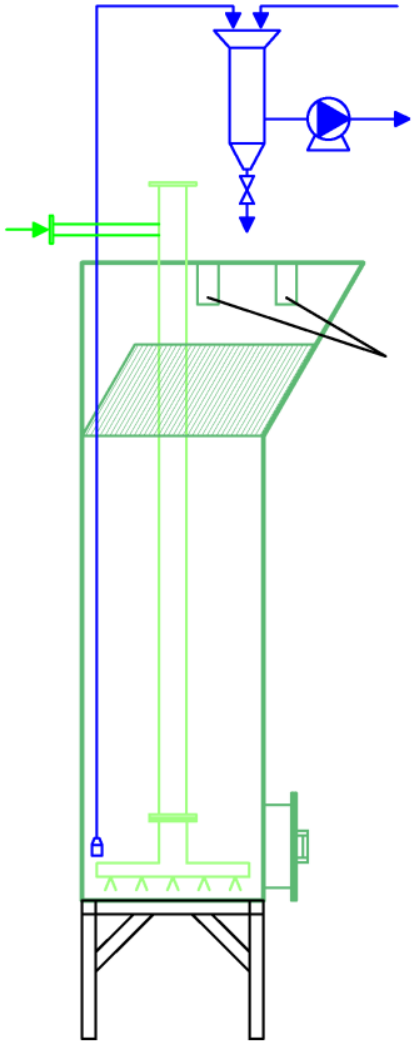
Kluizen IEX in fluidized bed

Kluizen 2013

- Regeneration system
- Inlet construction
- Conventional IEX resin



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Kluizen IEX in fluidized bed

Conclusions Kluizen 2013

- Coagulant dose reduction > 80%
- Improved overall DOC removal efficiency
- Lower mineralisation
- Investment cost compensated by lower operational cost (chemicals, sludge removal)
- Stable operation

- Waste water treatment: coagulation + dewatering

  ⇒ further research towards more sustainable solution

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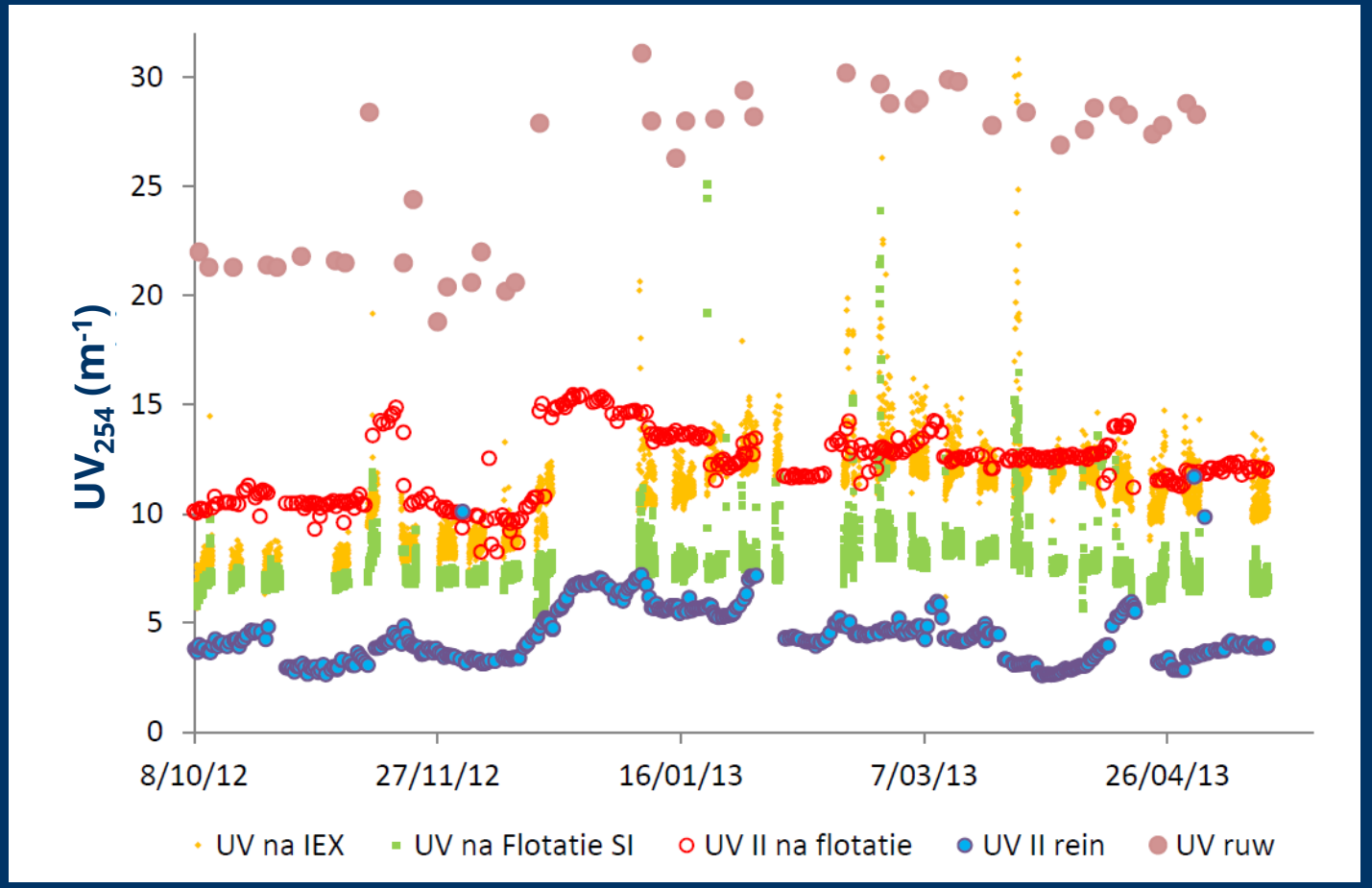
Kluizen IEX combined with flotation



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Blankaart IEX in fluidized bed

50 m³/h IEX pilot plant

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Blankaart flotation pilot

25-40 m³/h flotation pilot plant

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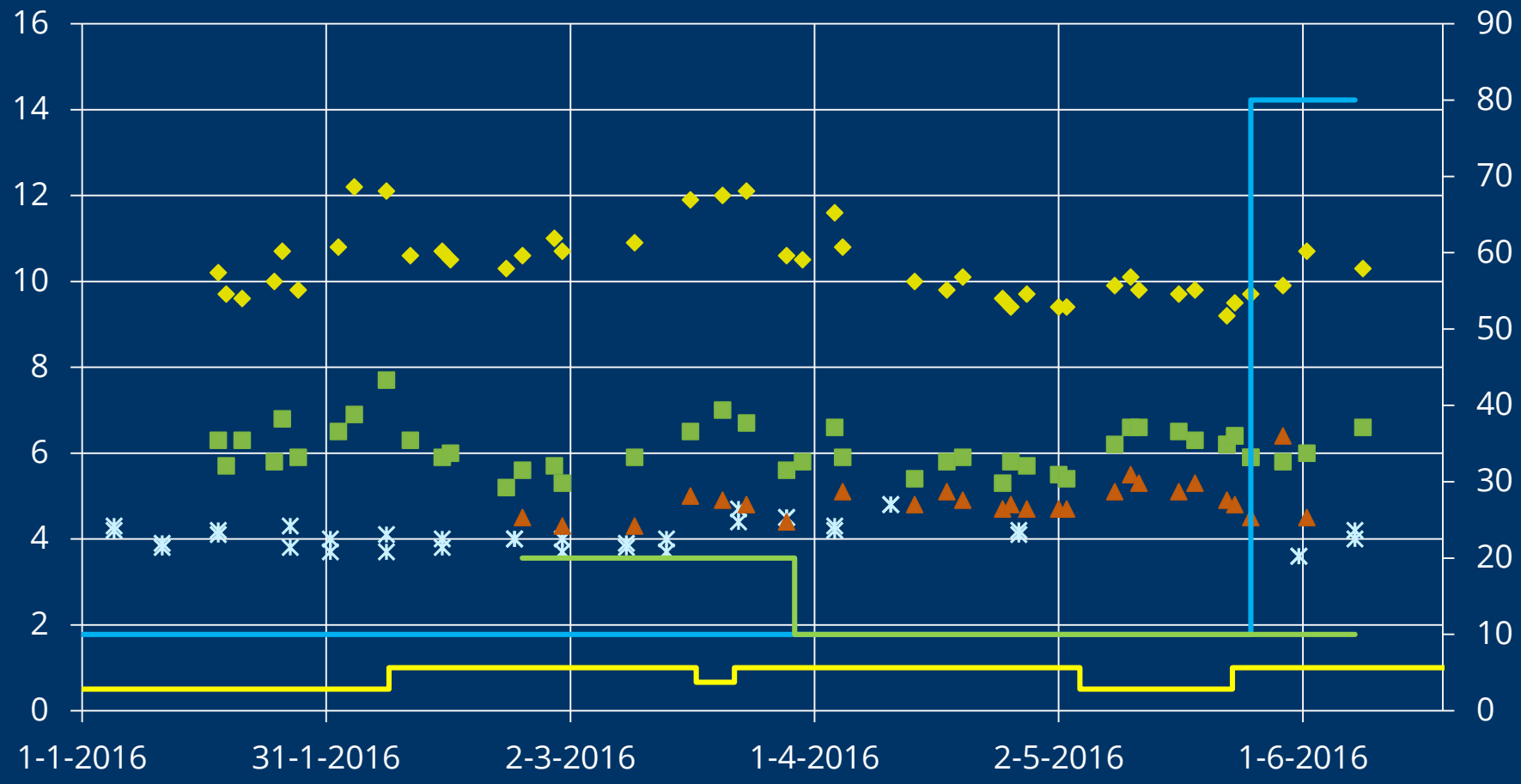
Blankaart pilot – first results



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Blankaart pilot – first results

Comparison with results Kluizen

	IEX		IEX + flotation	
	NPOC reduction (%)	UV_{254} reduction (%)	NPOC reduction (%)	UV_{254} reduction (%)
Kluizen, IEX 0.5 ml/l	43	68	49	75
Blankaart, IEX 0.5 ml/l	37	52	47	58
Blankaart, IEX 1.0 ml/l	44	60	52	62

Full scale floc removal	
NPOC reduction (%)	UV_{254} reduction (%)
41	50
61	72

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Blankaart pilot – first results

- Stable operation
- Coagulant dose reduction > 50%
- No improvement of overall DOC removal efficiency
  at low resin dose (0.5 – 1.0 ml/l)

- Further increase of the resin dose? ⇒ larger regeneration vessel

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IEX waste water treatment

- Goals
  - Zero liquid discharge
  - Separation of salts and DOC
    - Reuse of salts for regeneration
    - Removal of DOC from the system (as a valuable secondary resource?)

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IEX waste water treatment coagulation & dewatering

- Technologically and economically feasible
- Filtrate can be recycled for brine production
- Filter cake = waste

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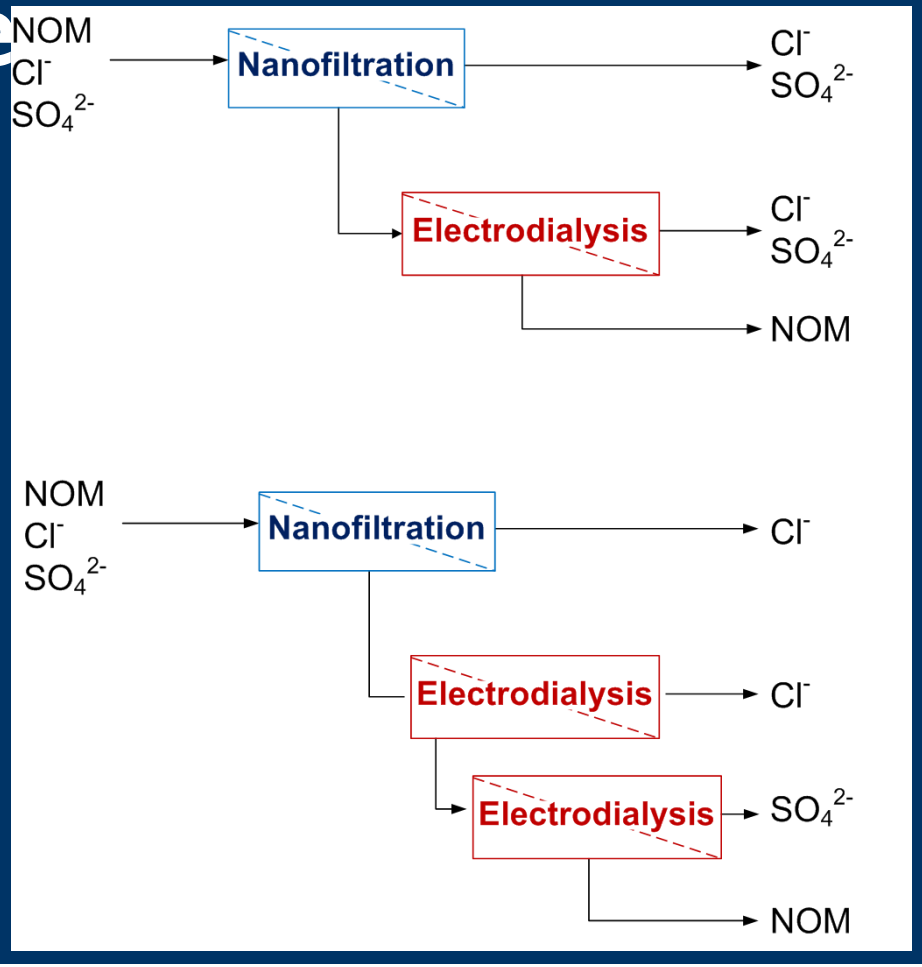
IEX waste water treatment – alternative treatment scheme

- Goal: DOC concentrate with low salinity
- Nanofiltration + electrodialysis
  - Uncontrolable fouling of NF membranes



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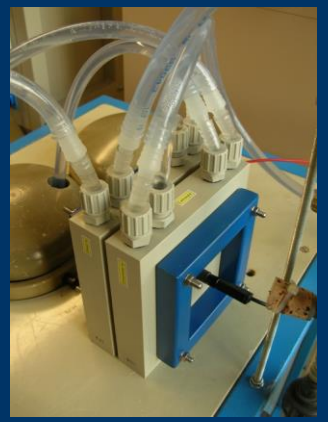
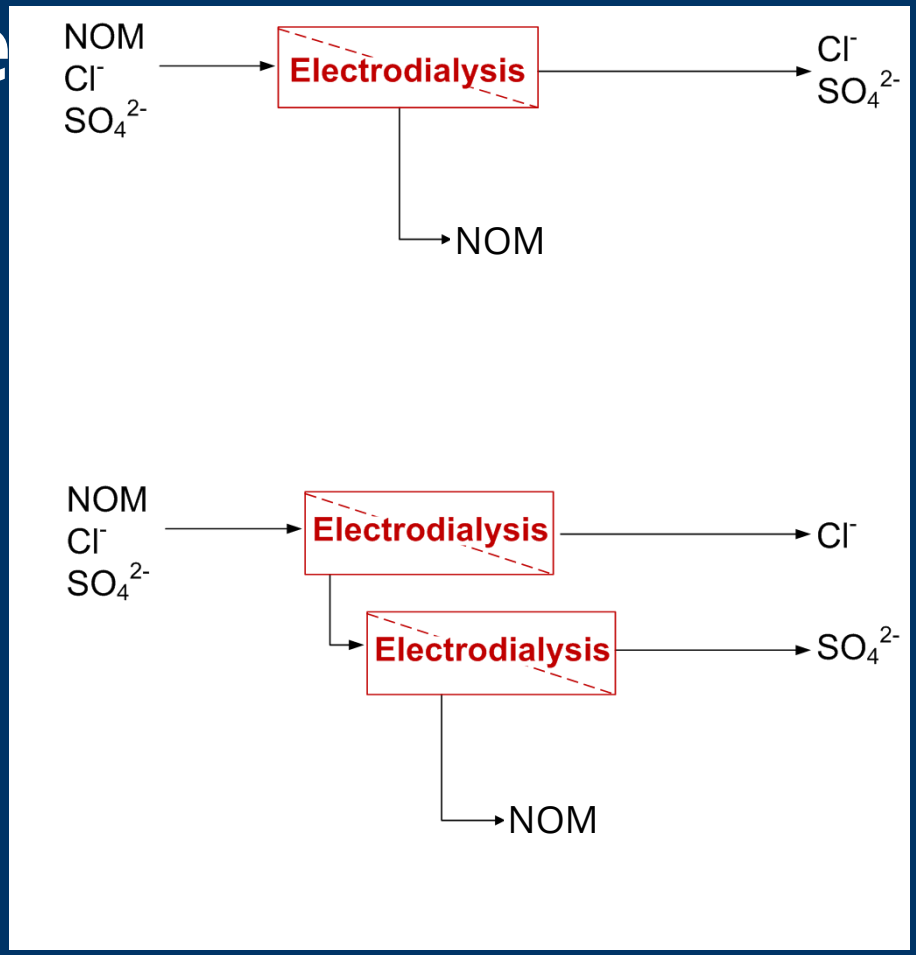
IEX waste water treatment – alternative treatment scheme

- Electrodialysis
  - Seems feasible, but significant operational cost
  - Long term behavior? Repeatability experiments
  - Concentration of DOC? e.g. evaporation technique?





IEX waste water treatment – DOC as a valuable end product?

- DOC concentrate as a growth stimulator in agriculture
  - Salts content still too high?
  - Wrong type of DOC components?

- Important to get an idea of the economic value!

  ⇒ DOC characterisation?

  Required desalination level?

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Conclusions so far

Fluidized bed IEX – coagulation – flotation

- IEX
  - Stable operation possible, even during algae blooms
  - Slightly higher NOM removal efficiency in Kluizen compared to Blankaart
- Impact on optimal coagulant dose
  - > 80% reduction in Kluizen
  - > 50% reduction in Blankaart
- IEX pretreatment resulted in higher overall DOC removal efficiency in Kluizen, no improvement (with low resin doses tested so far) at the Blankaart
- Lower mineralisation of treated water

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Conclusions so far

IEX waste water treatment

- Coagulation and dewatering
  - Technologically and economically feasible
  - Zero liquid discharge
  - Salts recycled to regeneration process
  - Filter cake = waste
- Alternative treatment strategies
  - Nanofiltration: serious problems with membrane fouling
  - Electrodialysis: feasible at significant operational cost
  - No conclusions so far with respect to economical value of DOC end product

Ongoing research

IEX	• Impact of resin dose on DOC removal efficiency and DBP FP • Impact of regenation process and brine composition on DOC removal efficiency • Translation to full scale
Flotation	• Optimal coagulant dose and coagulation pH • Flocculation time and hydraulic loading of flotation plant
Waste water	• Economical value of DOC concentrate • Alternative treatment schemes aimed at valorisation of DOC

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