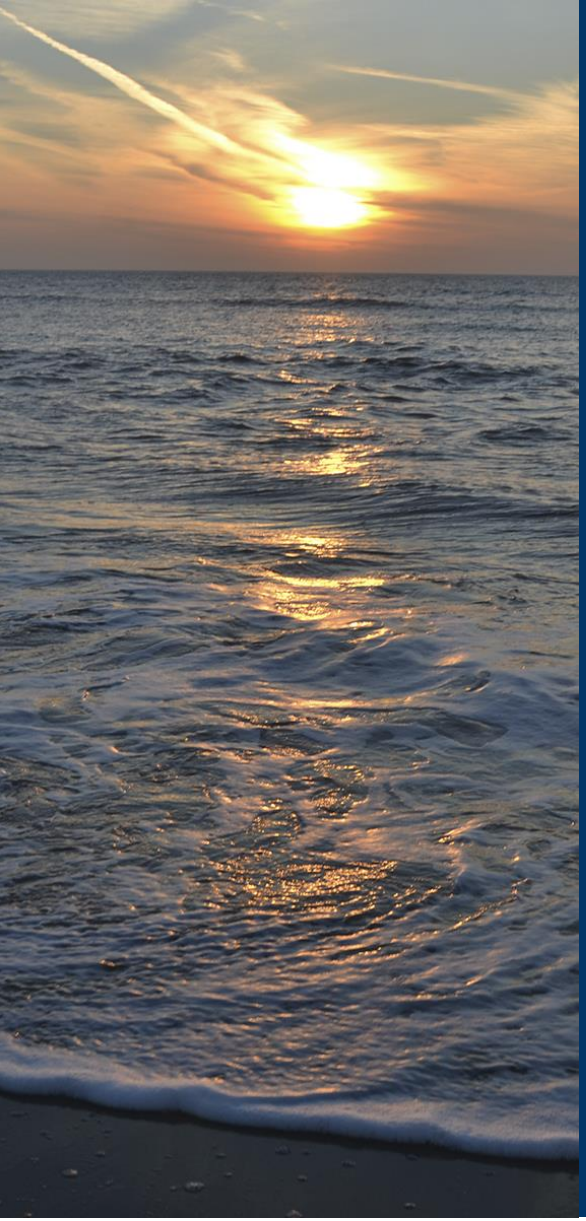

DOC R&D PWN(T)

summary 2018

G.Galjaard, PWNT

November 2018, Plymouth

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PWN Water Supply Company North-Holland

- source is mainly (very challenging) surface water (95%)
- 787.000 connections
- 1.7 million customers
- 105 million m^3 of drinking water per year
- water price in 1,31 Euro per m3 (2018)
- Approx. 500 employees
- 5 WTP's and 2 pre-treatment plant for artificial recharge

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PWN Water Supply Company North-Holland

source challenge PWN

- most of the Provence is below sea level
- groundwater is salt in other area's then the dunes
- only available source is the IJssel Lake
- IJssel Lake is dominantly fed by the river Rhine
- under the influence of industry, recreation, population
- high contamination level (delta of Europe)

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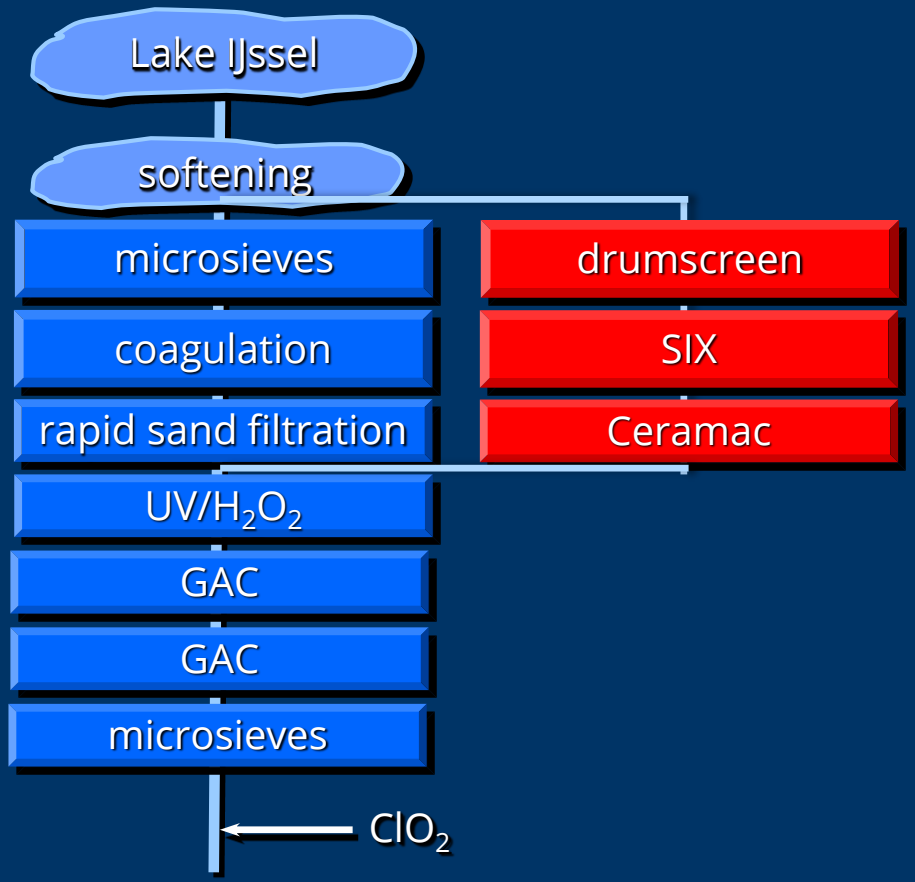
PWN Water Supply Company North-Holland

WTP Andijk 2018



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content

Update DOC related R&D within PWN(T) in 2018

- source challenges (IJssel Lake) and changes
- adding in-line coagulation (ILCA®) after SIX® at WTP Andijk
- further developments within SIX®-technology
- new technologies tested (i.e. Arvia Nyex ™)
- brine treatment, recovery of humic substances

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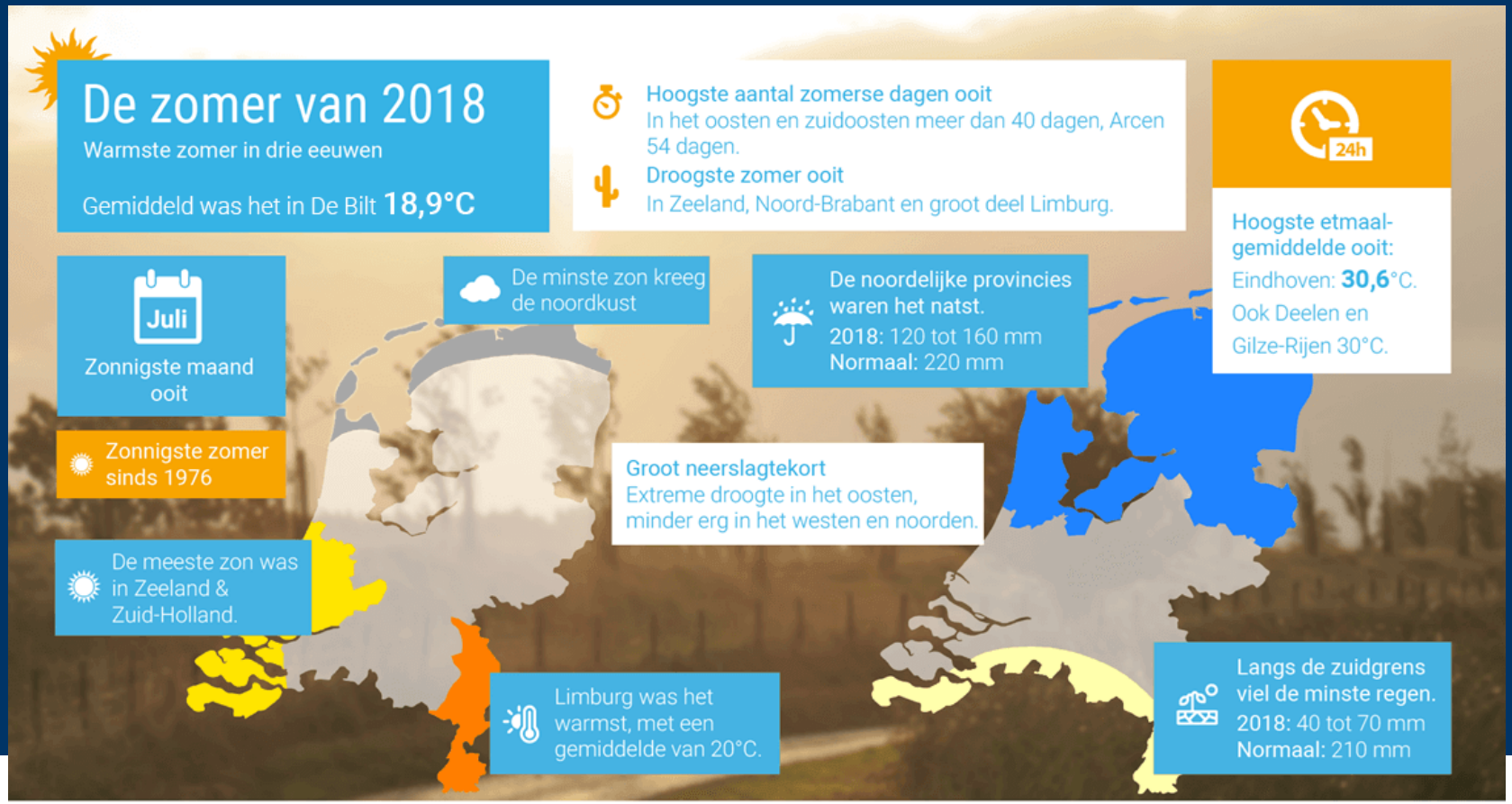
source challenges and changes

2018, a very hectic year for the Rhine river Delta



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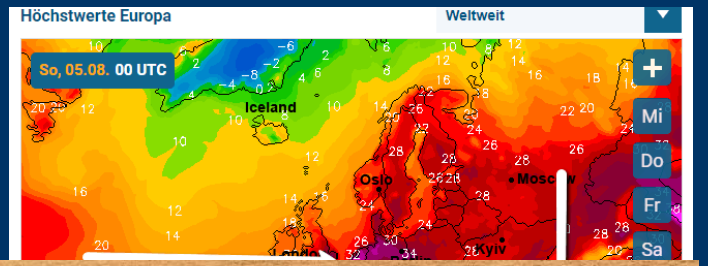
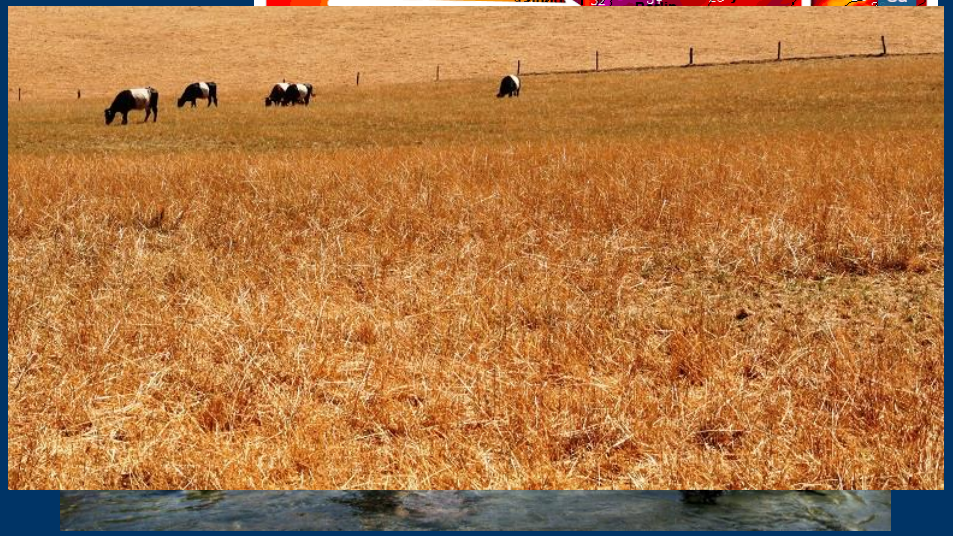
source challenges and changes

2018, a very hectic year for the Rhine river Delta

- extreme warm weather (April-October)
- extreme dry weather (since May)
- multiple meteorological records were broken
  - warmest nights
  - warmest months
  - lowest amount of rain
  - lowest water level in the Rhine





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IJssel-
meer

IJssel
15,9%

A N D

58,3%

31,6%
Nieuwe Maas

Lek 11,3%

12%

12,6%
Nederrijn

Pannerdensch Kanaal
28,6%

Amsterdam-
Rijnkanaal

Scheur

Oude Maas

Noord 20%

BM 27,4%

Boven-
Merwede

Waal

71,3% Waal

Spui
4,9%
+ 1,3%

21,7%
+ 3,7%

DK
14,6% + 3,7%

7%

NM 43,8%

Afgedamde
Maas

Maas
11,3%

Maas-
Waal-
Kanaal

Rijn
100%

Haringvliet
24,2% + 6,2%

Hollands Diep
29,2% + 7,6%

Amer

Bergsche Maas
11,3%

Maas
11,3%

Volkerak

Ooster-

Schelde-
Rijn-
Kanaal

Rijn = 12.000 m³/s → Haringvliet = 8.000 m³/s
Rijn = 2.000 m³/s → Haringvliet = 400 m³/s
Rijn < 1.000 m³/s → Haringvliet = 0 m³/s

BM = Beneden-Merwede
DK = Dordtse Kil
NM = Nieuwe Merwede

Schelde

Schelde-
Rijn-
Kanaal

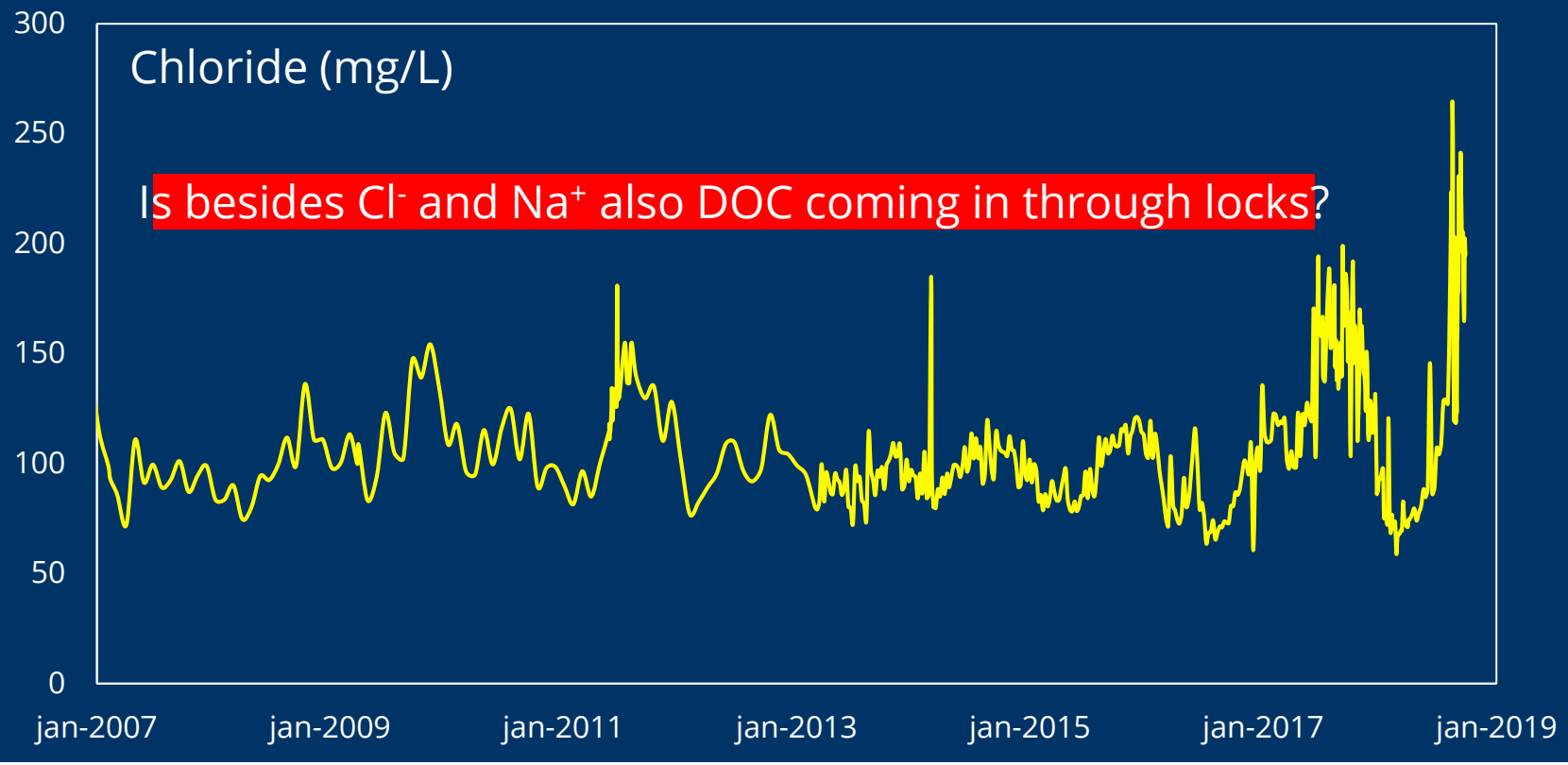
Westerschelde

DUITSLAND

100% Maas = 11,3% Rijn
Maas + Rijn = 111,3%
De weergegeven percentages zijn berekend ten opzichte van hoeveelheid water in Rijn en Maas ter hoogte van de grens

source challenges and changes

chloride concentration IJssel Lake



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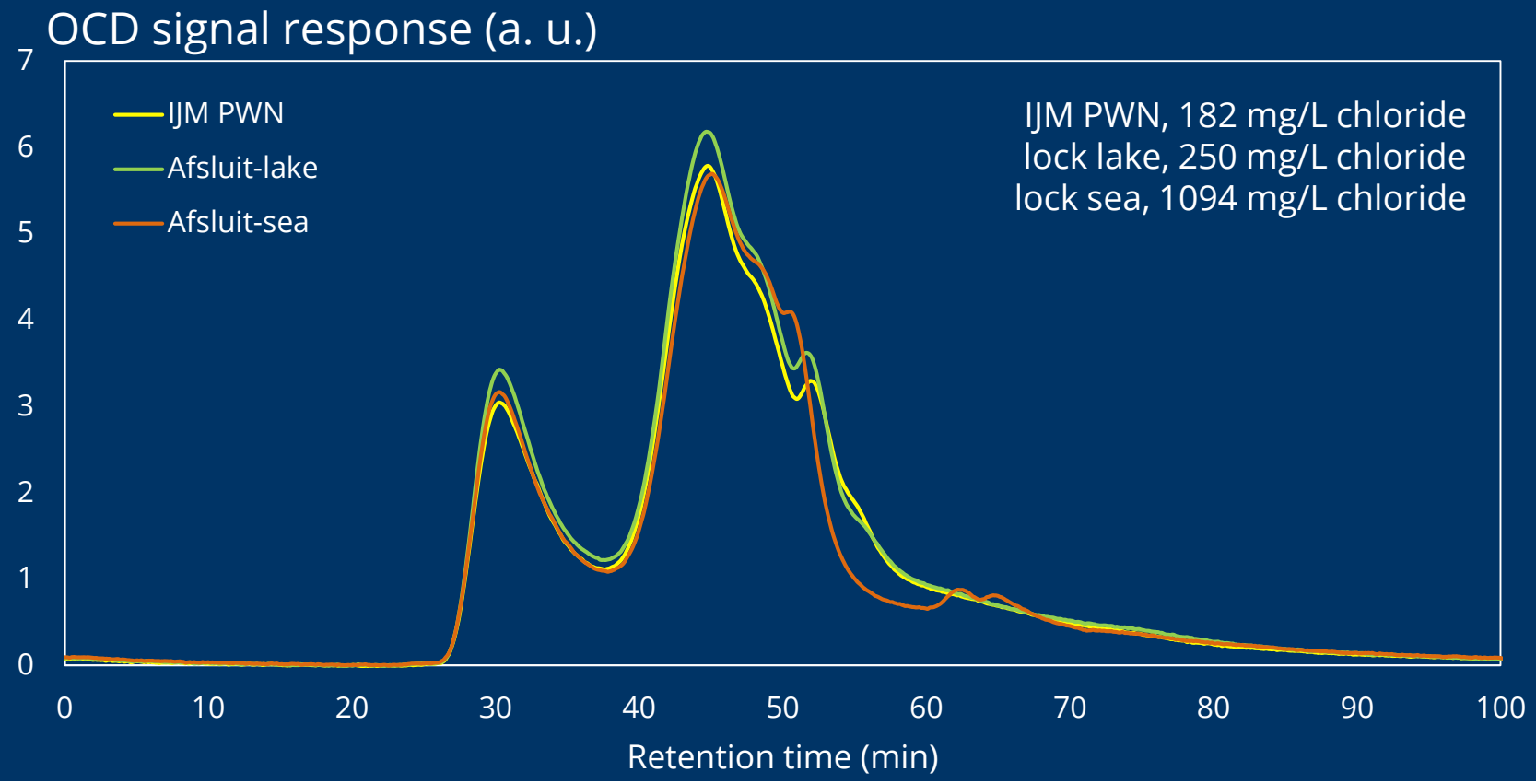
source challenges and changes

NOM Waddenzee vs IJssel Lake



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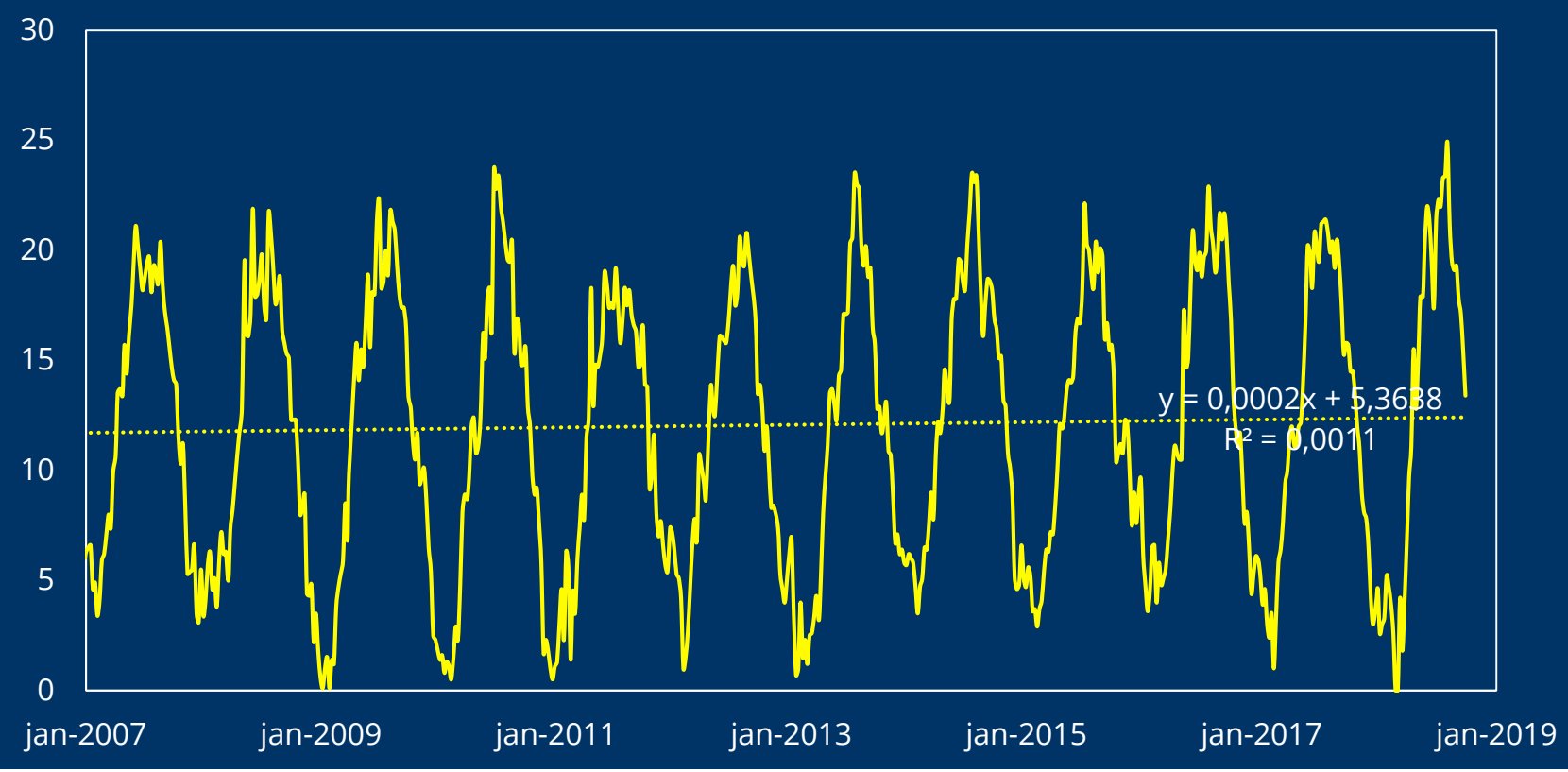
source challenges and changes

Temperature IJssel Lake



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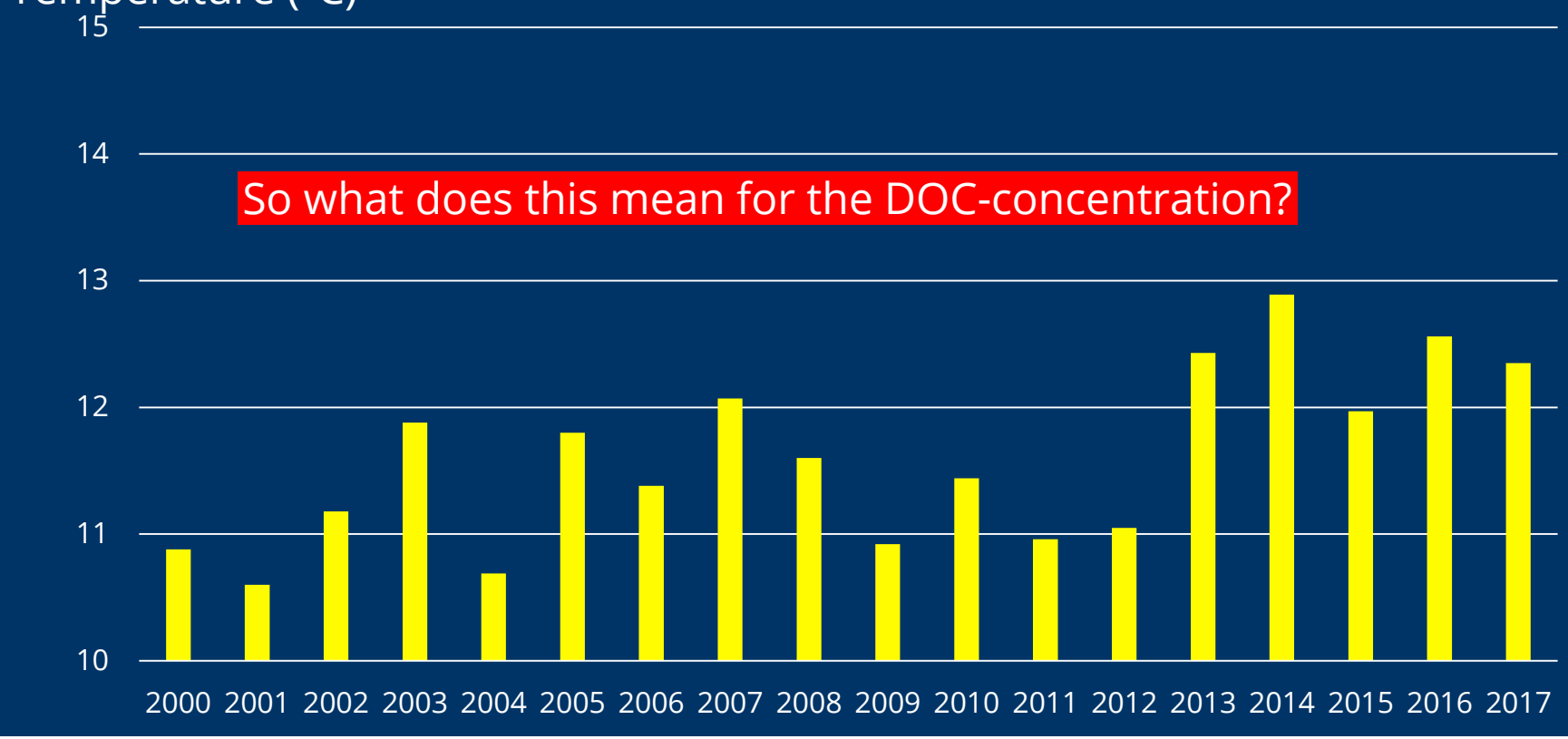
source challenges and changes

IJssel Lake – average raw water temperature



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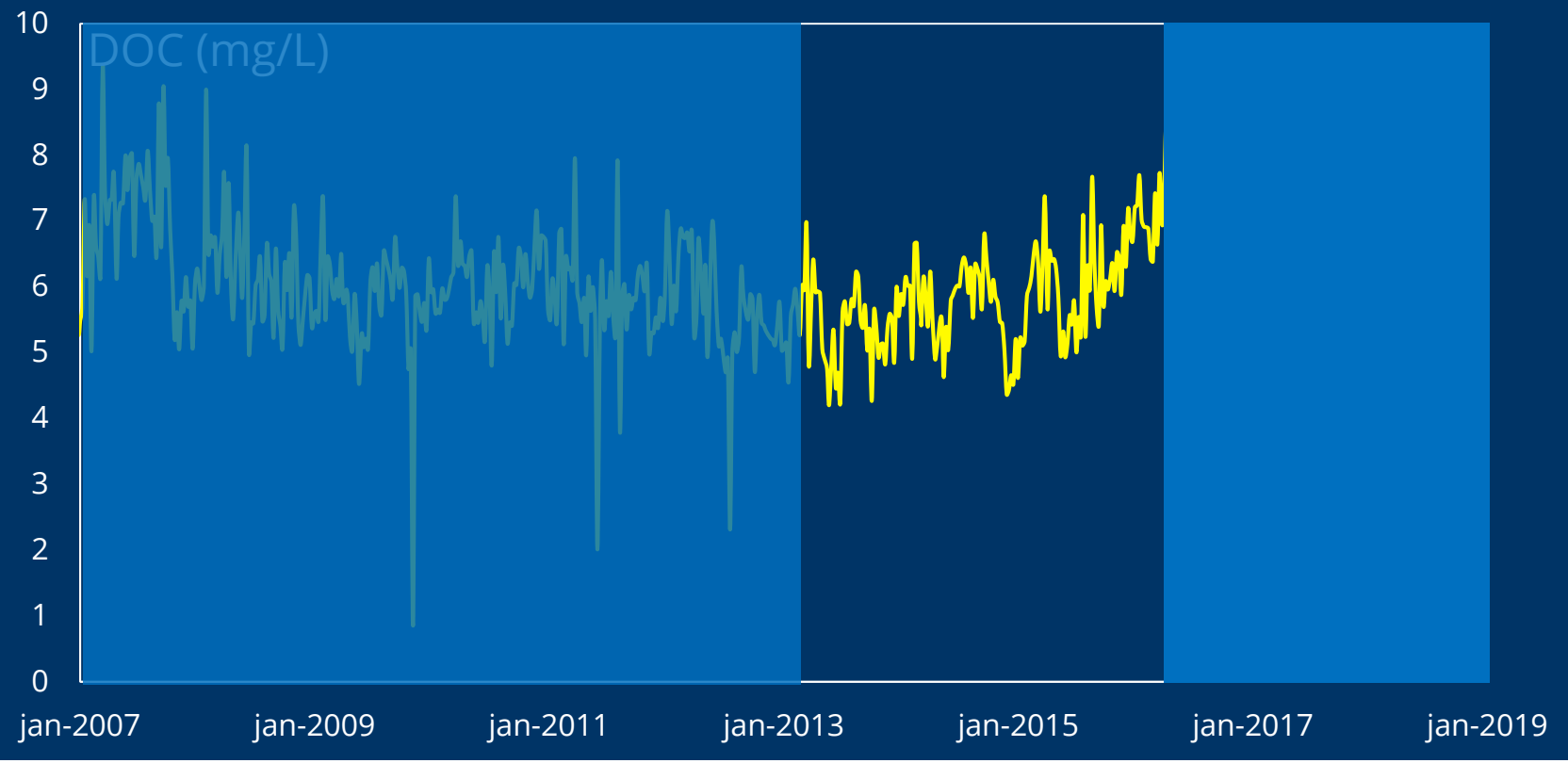
DOC IJssel Lake



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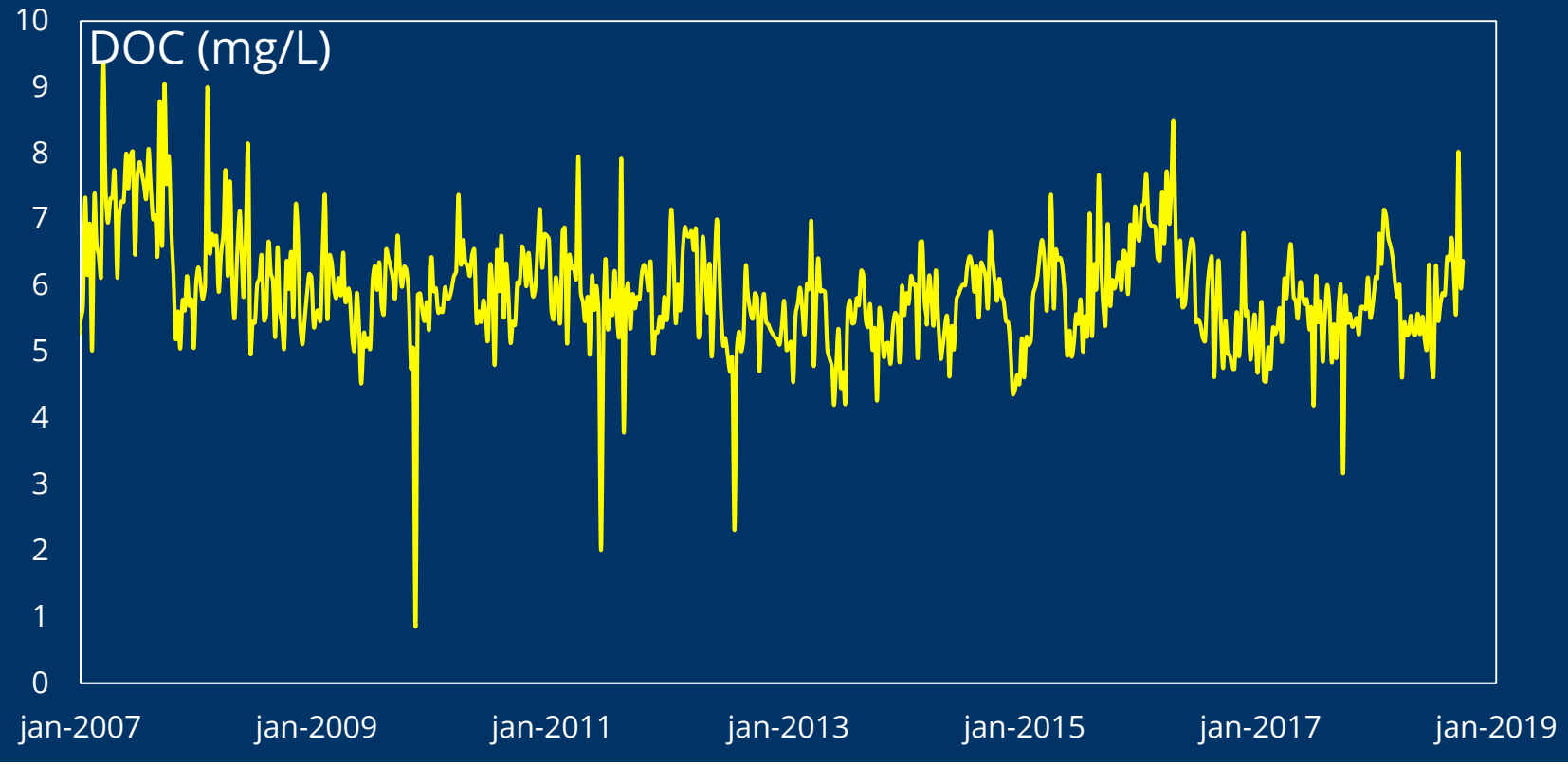

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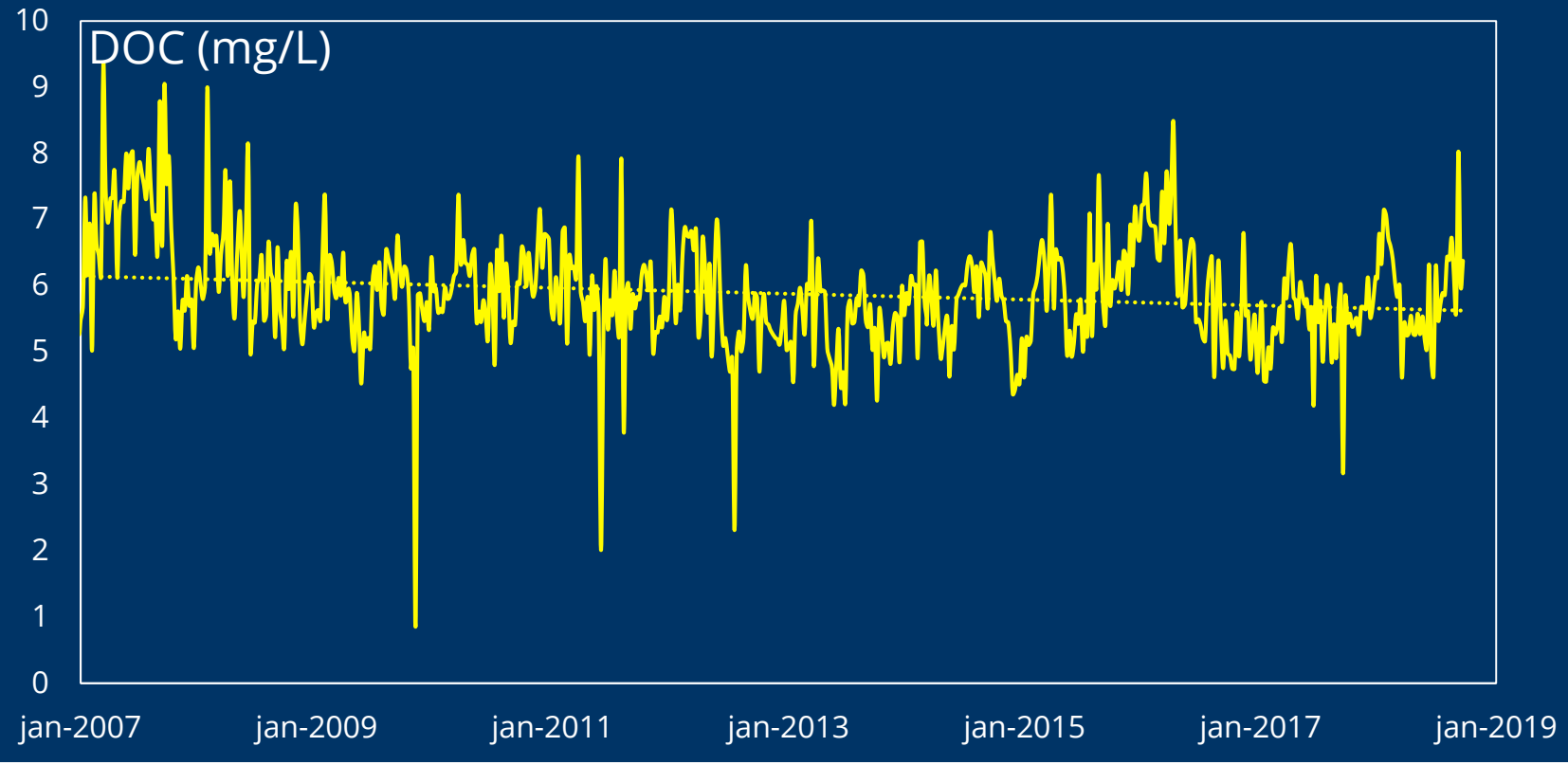
DOC IJssel Lake



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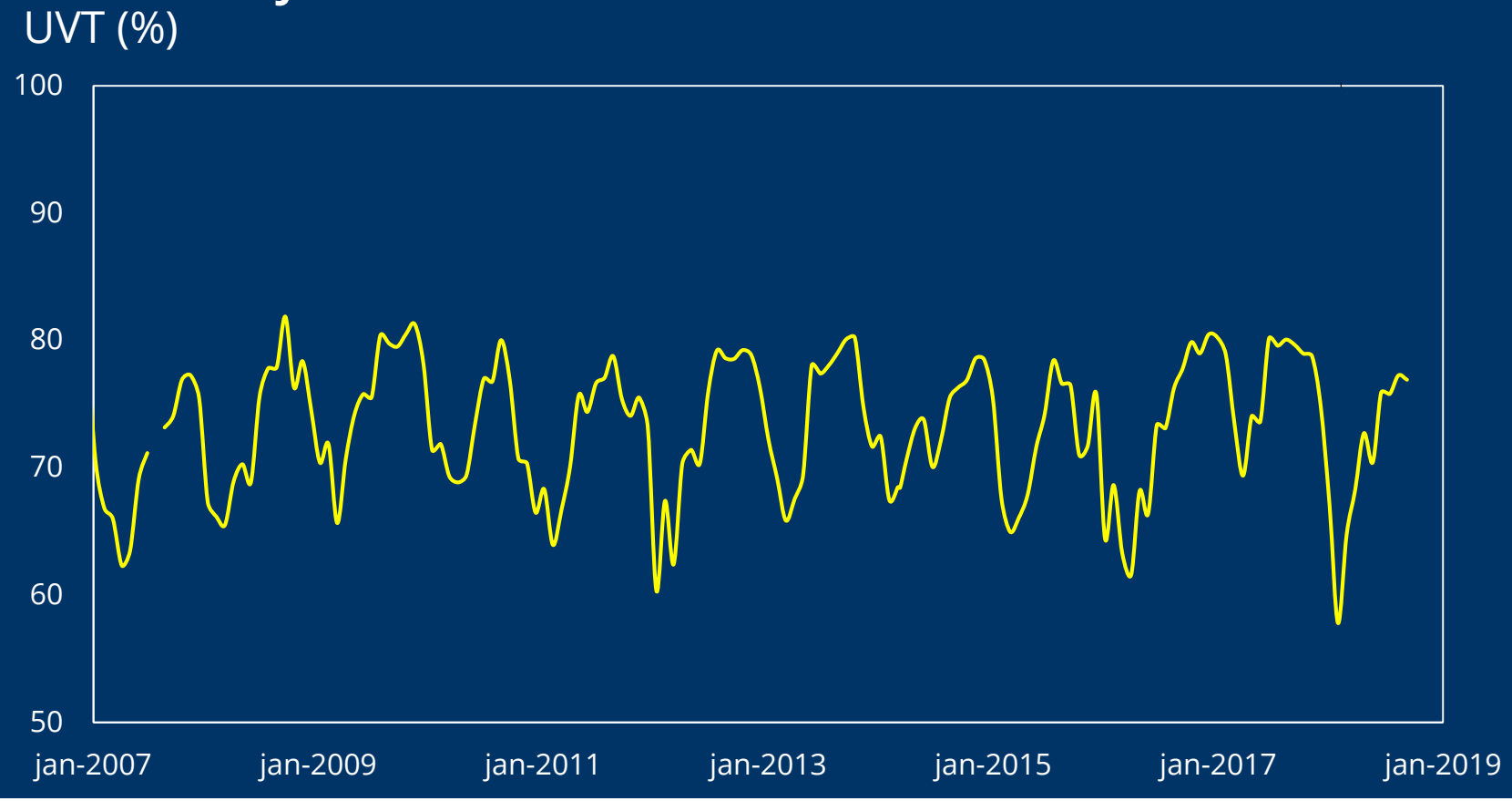
UVT254nm IJssel Lake



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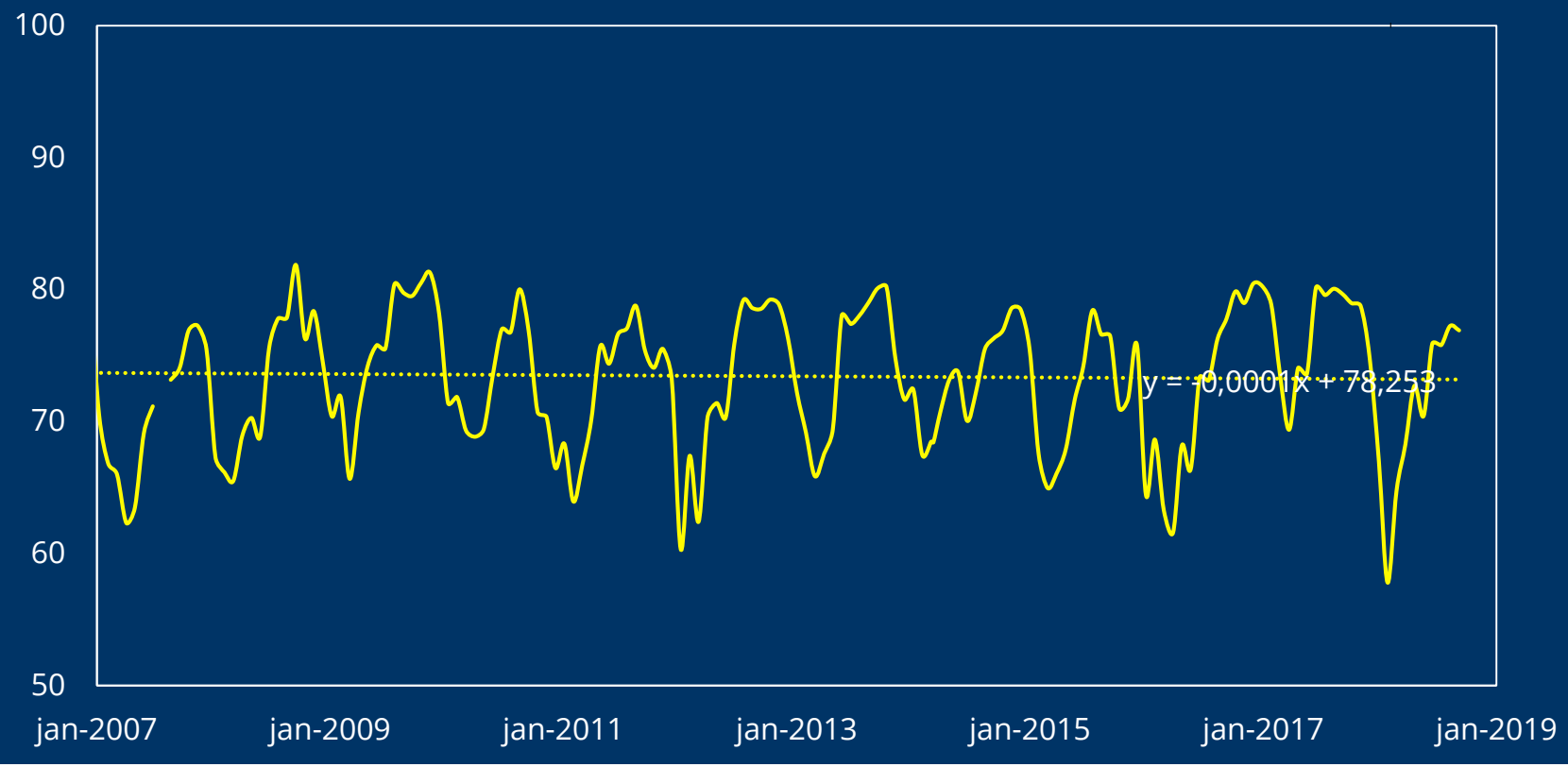
UVT254nm IJssel Lake



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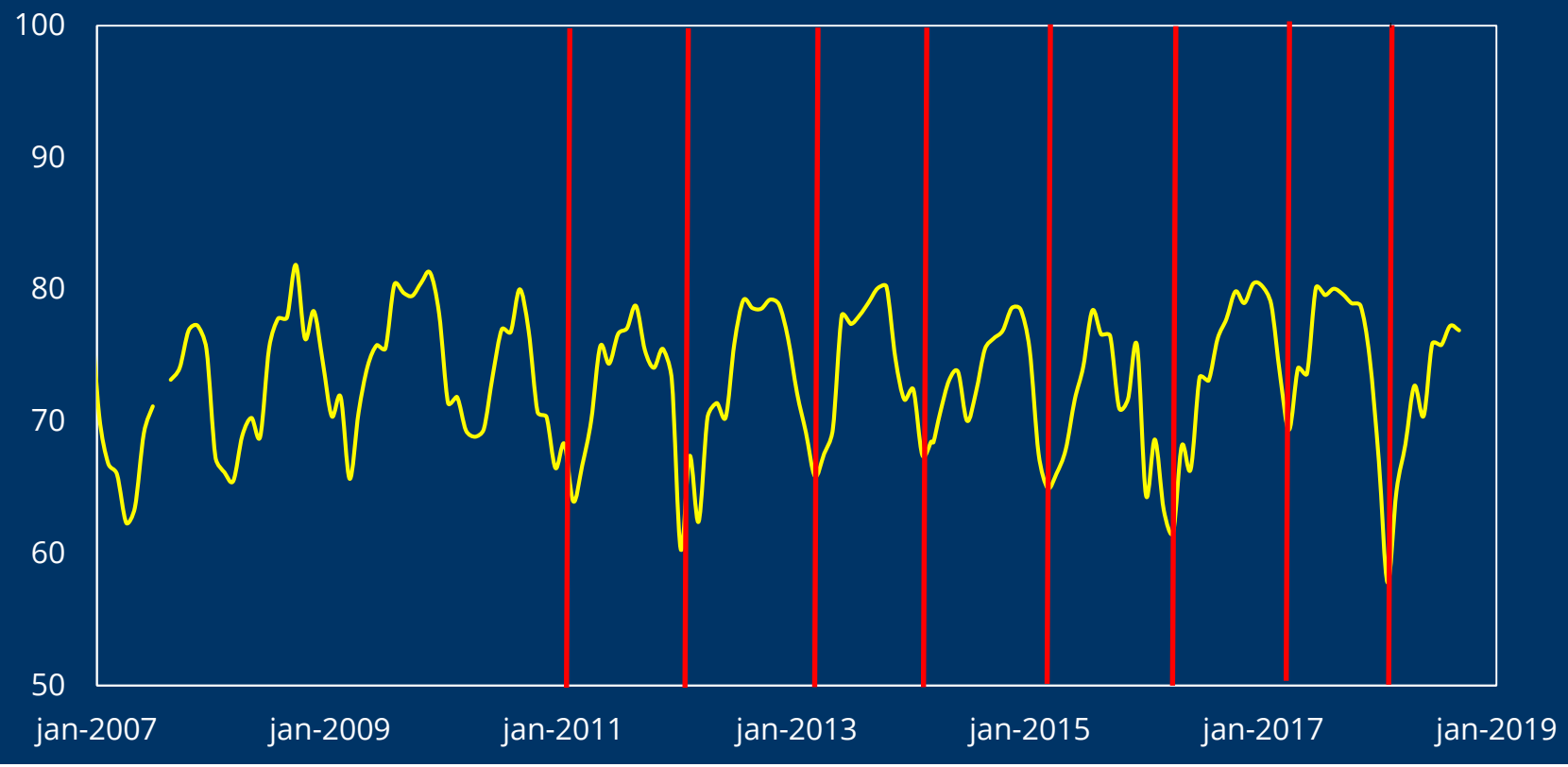
UVT IJssel Lake



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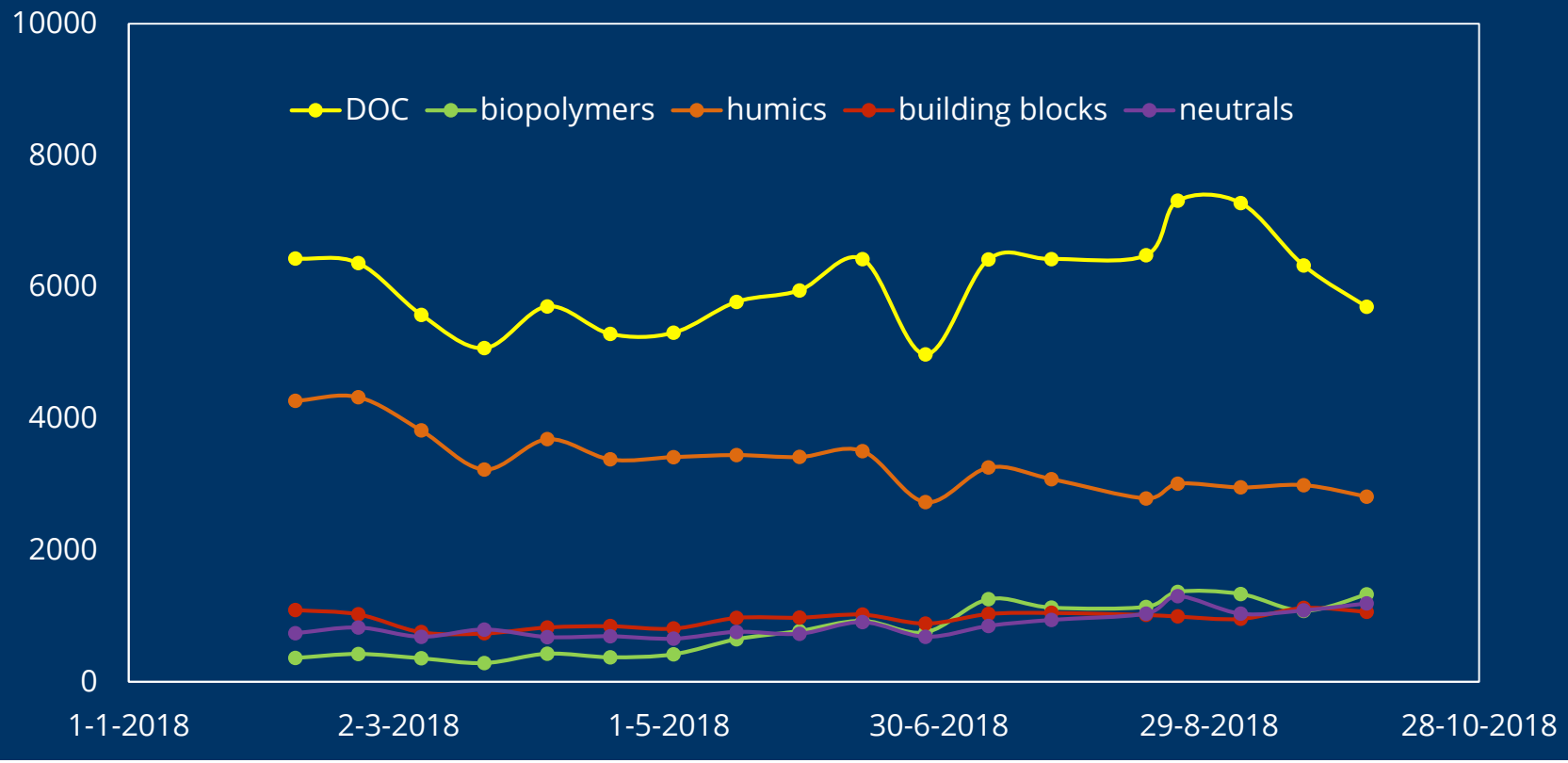
LC-OCD IJssel Lake

DOC and NOM fractions (µg/L)



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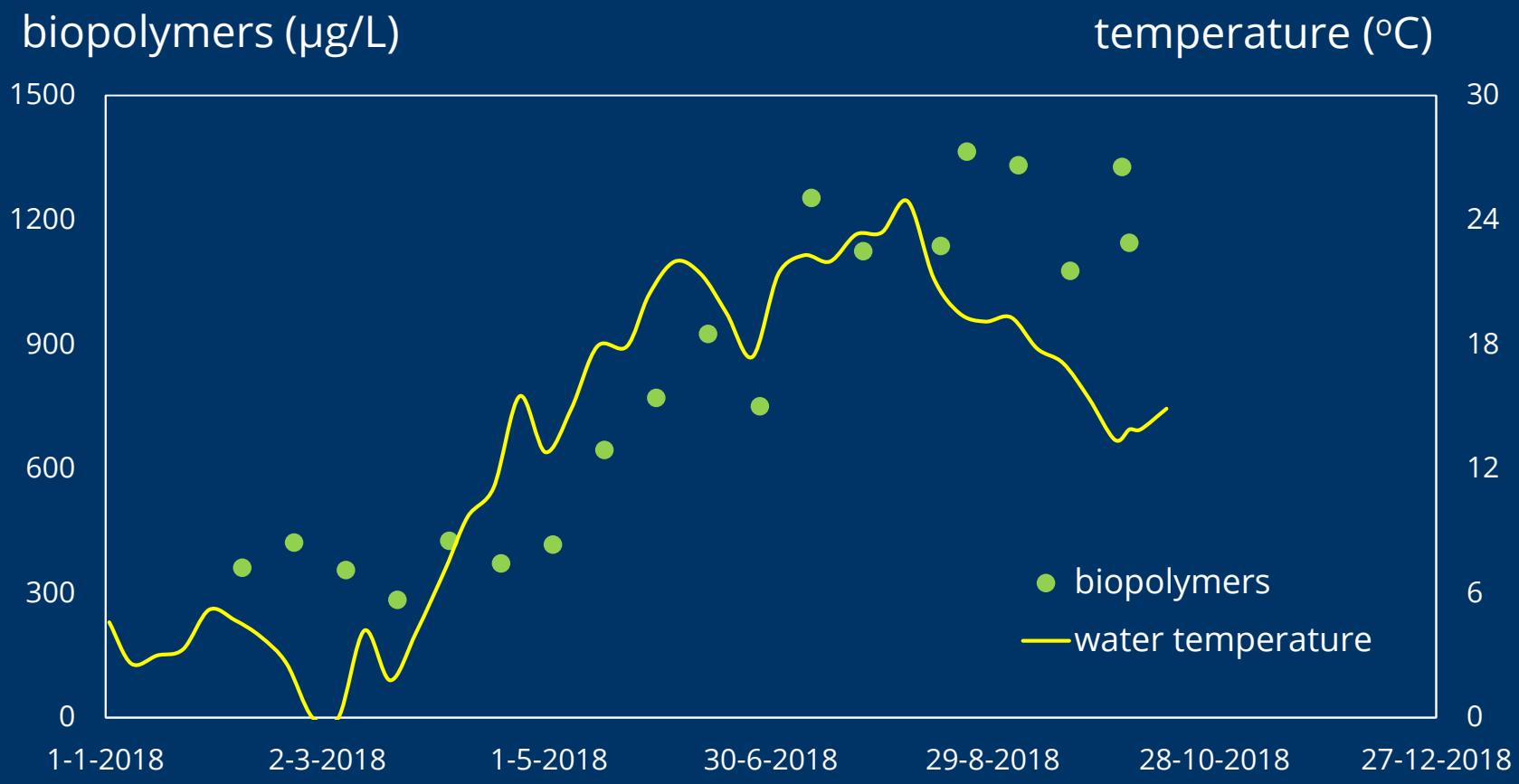

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Source challenges and changes

discussion & future research

- higher monitor input and modelling source changes coming years
- appears to be a DOC change to higher concentration HMW biopolymers
- increase in biopolymers seems temperature related?
- current pretreatment WTP Andijk sensitive for HMW organics
- R&D to enhance operation (flux) with ILC for WTP Andijk
- now ILC also focus on biopolymer removal

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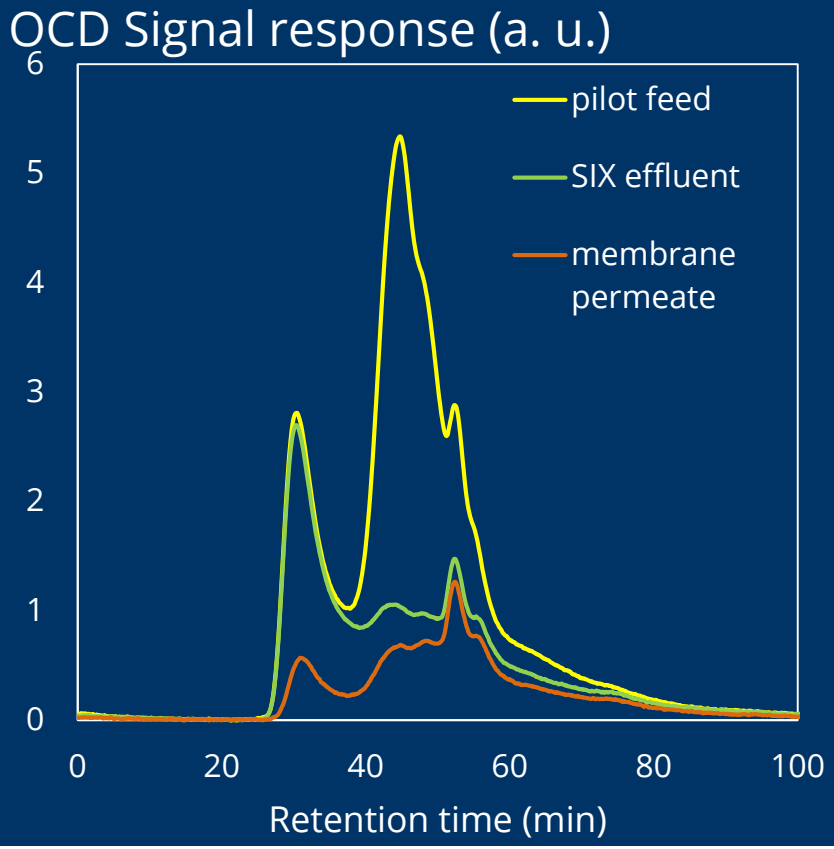
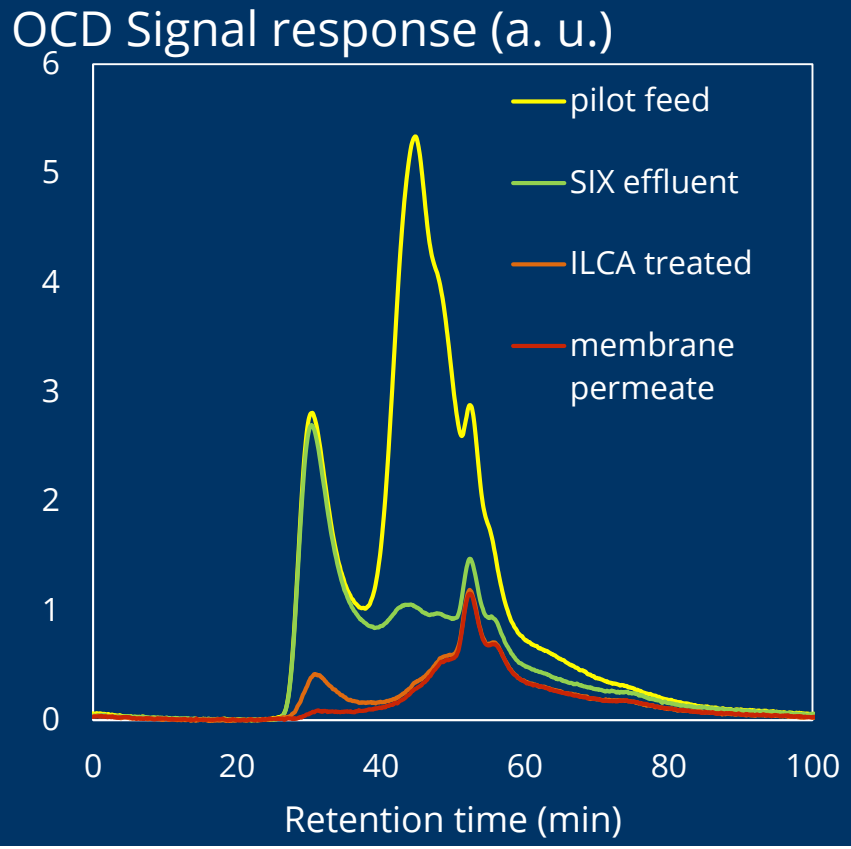
source challenges and changes

Impact in-line coagulation after SIX for WTP Andijk





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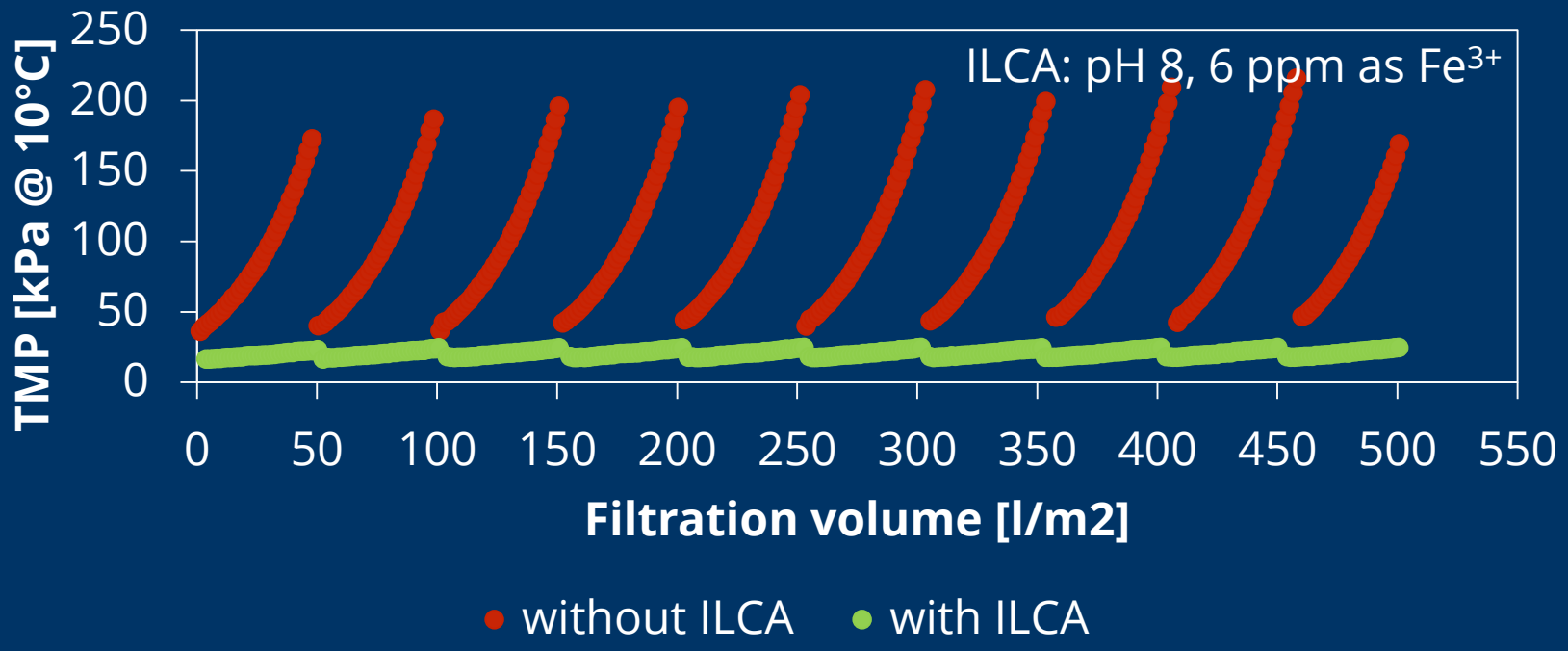

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PWNT's C90 Ceramic Microfiltration at WTP Andijk

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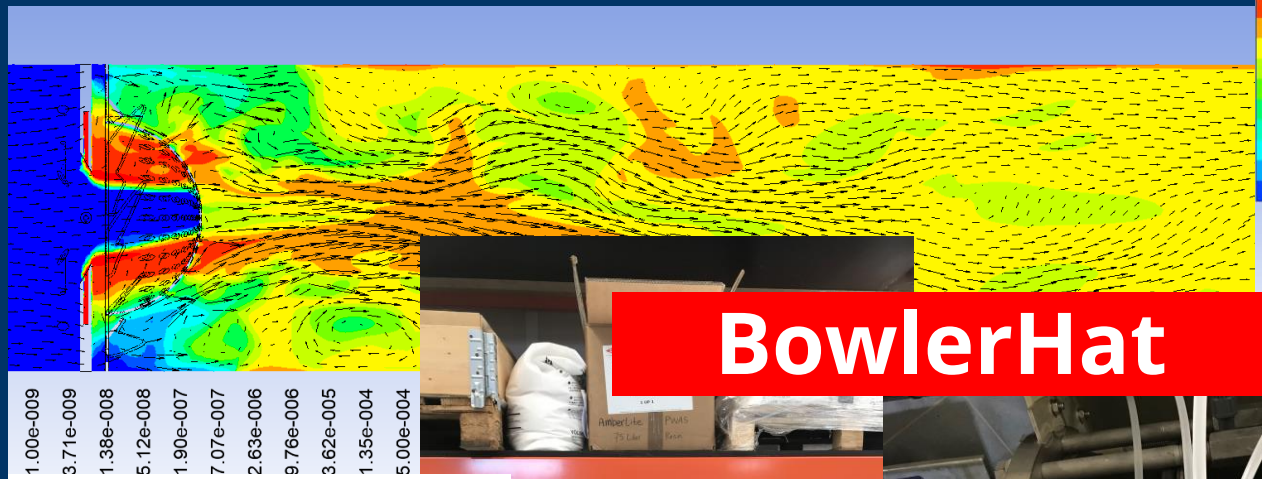
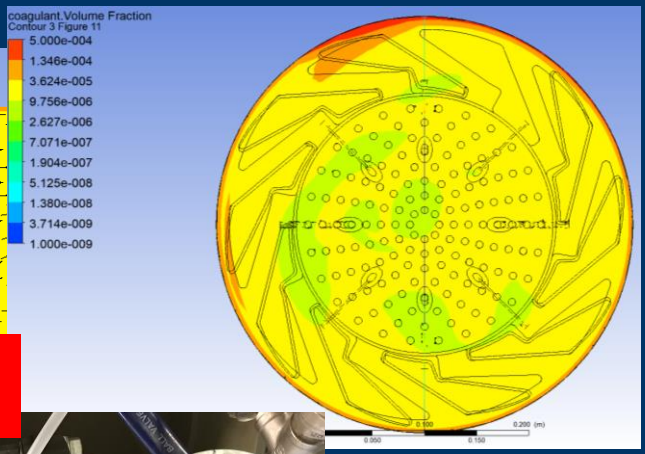
adding ILCA® at WTP Andijk

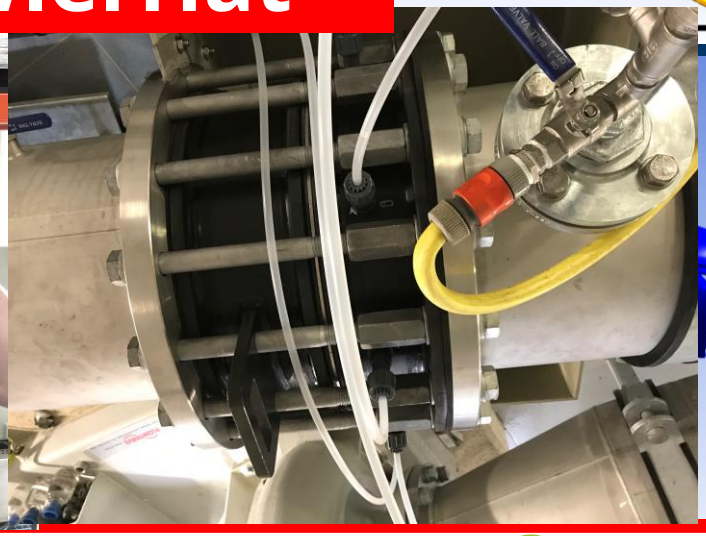
fast mixing coagulant in a pressurized system

Mixing coagulant volume fraction in the reference cross section, 3d downstream of the injectors





BowlerHat



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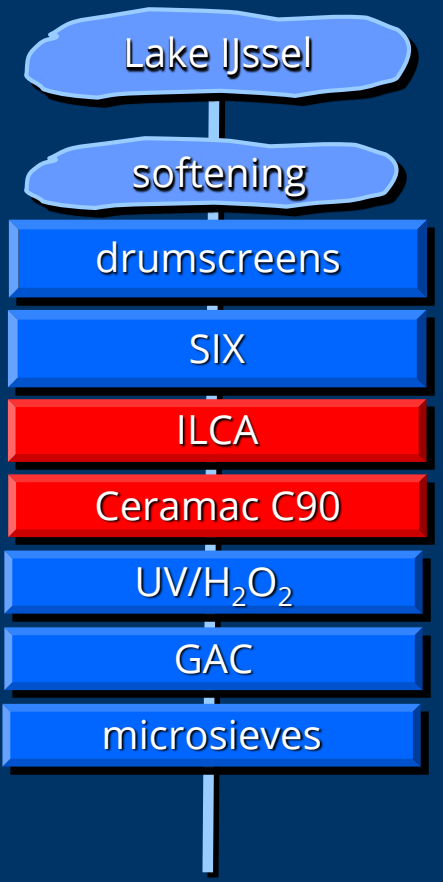
source challenges and changes

WTP Andijk, 2020



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new DOC-removal technologies tested

Arvia Nyex^{tm}, bench scale tests, WP3, SME's

Figure 2. Modular design of Arvia's Nyex™ treatment system which treats water by adsorbing organic contaminants from the influent as it percolates the packed bed of Nyex™ particles, and the simultaneous passing of current ensures in situ oxidation of the adsorbed organic.

Figure 9. Before(left) and after treatment(right) for E1

Initial bench scale tests promising but needs to be piloted to validate feasibility

Table 4. Micropollutant analysis results

Compound	Removal		
	Saturation	A9	A10
10,11-trans diolcarbamazepine	57.8%	63.0%	60.1%
acetylsulfamethoxazole	100.0%	100.0%	100.0%
atenolol	100.0%	100.0%	100.0%
bisoprolol	100.0%	100.0%	100.0%
carbamazepine	91.1%	97.8%	97.0%
coffeïne	86.8%	1.1%	35.6%
fenazon	-40.1%	81.6%	88.7%
ifosfamide	0.0%	0.0%	0.0%
iopromide	75.3%	100.0%	47.0%
lidocaïne	100.0%	100.0%	100.0%
lincomycine	100.0%	100.0%	100.0%
losartan	100.0%	100.0%	100.0%
metformin	38.0%	76.4%	57.9%
metoprolol	100.0%	100.0%	100.0%
oxazepam	91.3%	100.0%	100.0%
primidon	-5.0%	20.0%	15.0%
propranolol	100.0%	100.0%	100.0%
sotalol	100.0%	100.0%	100.0%
sulfamethoxasol	48.2%	88.5%	86.0%
temazepam	85.7%	76.2%	38.1%
theophylline	96.6%	100.0%	100.0%
trimethoprim	100.0%	100.0%	100.0%
acesulfaam	1.5%	21.9%	20.6%
cyclamaat	7.8%	18.8%	14.1%
saccharine	14.1%	25.0%	29.7%
sucralose	100.0%	19.0%	-51.8%

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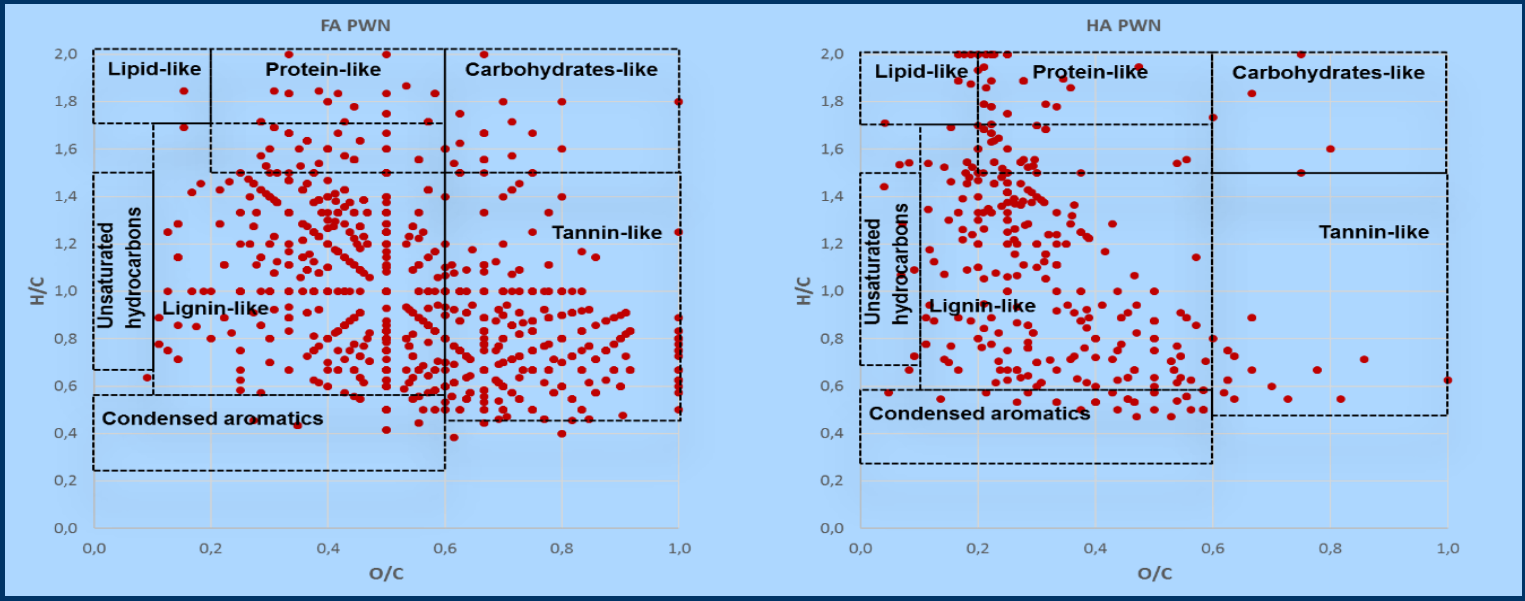
new DOC characterization methods tested

exploration of HA and FA molecules with mass spectrometry (Orbitrap)



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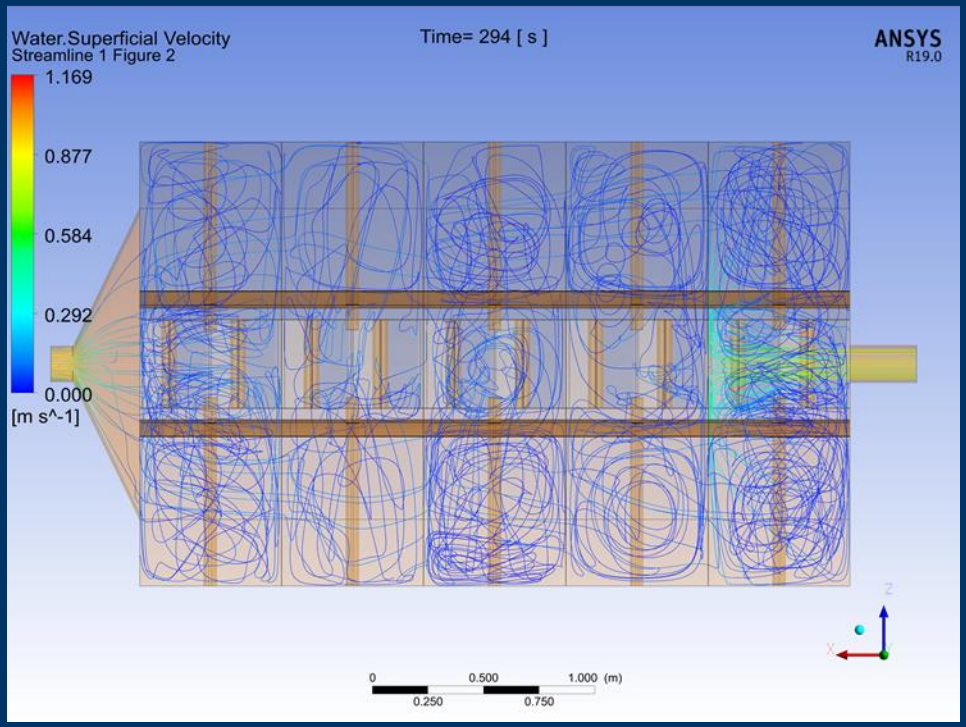
further development in SIX®

optimalisations working to 3th and 4th generation

- CFD to improve reactor design
  - improve CT
  - lower footprint
  - lower air consumption
- improve regeneration



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brine treatment SIX®

research on re-use and recovery

- currently brine WTP Andijk is discharged into the ground
- while this option is the lowest in costs it also has the lowest environmental impact (SimaPro) vs DNF-NF/RO-DVR or DNF-EDR-DVR
- however sentiment of discharge is negative so continuous research effort is put in treatment and re-use

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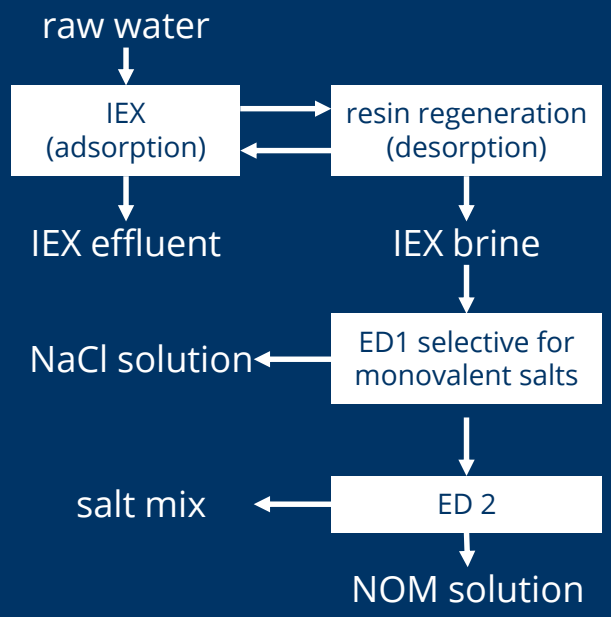
brine treatment SIX®

research on re-use and recovery

- IEX brine treated through two steps electrodialysis
  - NaCl recovery / concentrate ED 1
  - Demineralization of NOM / diluate ED 2
- membranes ED 1 made selective with addition of a second layer of tighter linked polymeric matrix
- micro-pollutants retention over IEX resin and transport through ED membranes examined



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De Watergroep WATER. VANDAAG EN MORGEN
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brine treatment SIX®

research on re-use and recovery

- humic substances as part of NOM include humic and fulvic acids, used in numbers of industrial application such a bio-stimulant in agriculture or feed enhancer in livestock farming
- previous assessment of the quality of humic substances recovered from IEX brine with electrodialysis inconclusive because of residual inorganic impurity level

- IHSS (international humic substance society) fractionation protocol produces
  - pure humic acids based on their precipitation properties at pH below 1
  - pure fulvic acids based on hydrophobic interaction on absorbent (non

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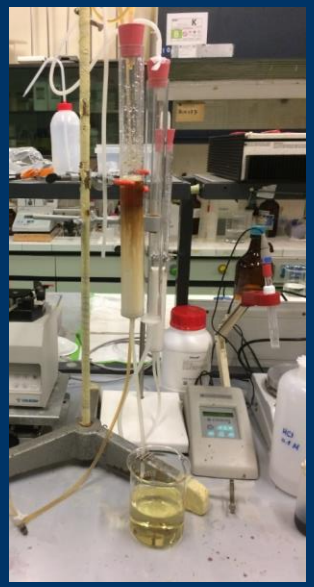
implementation and upscaling of the IHSS laboratory protocol

- labscale tests with DAX8
- elute HS with NaOH solution
- cation IX to exchange Na+ by H+

- upscaling process to pilot
  - pH optimization
  - resin selection
  - adaptation of rinsing and elution protocol



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10 kg HS produced for animal (pig) feed application test

- extraction pilot treated 50 m^3 mixed IEX brine (PWN & DWG)
- eluate, after de-ashing (Na+ removal), 2,5 m3
- concentration with RO membranes to 600L
- final product: HS 2w%

- sanitary acceptance trials to use these extracted HS for piglet feed are planned for January 2019

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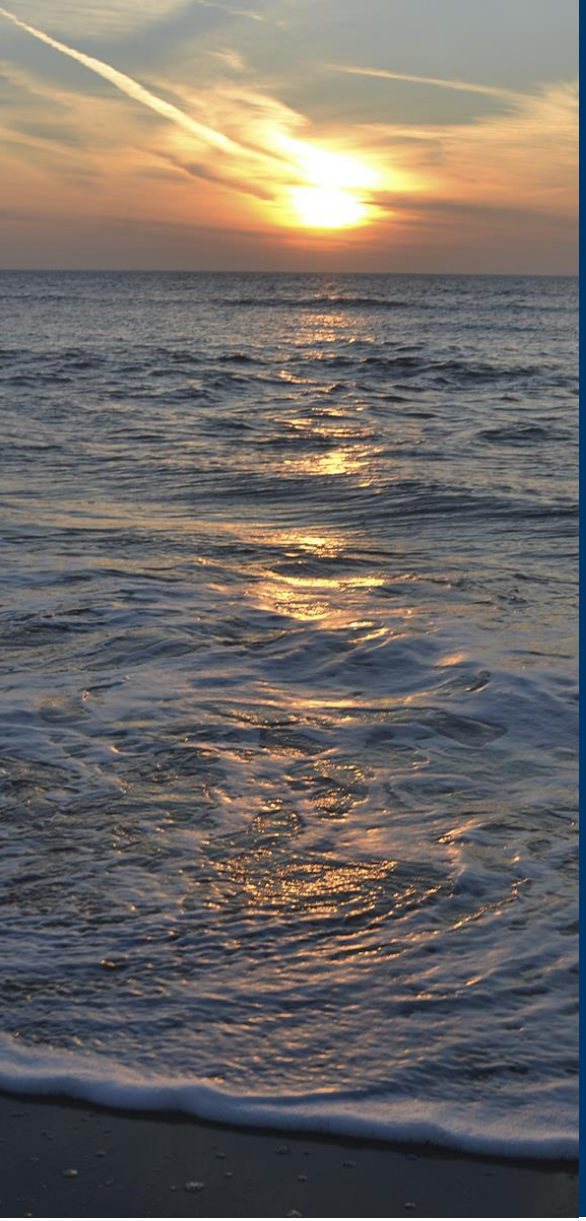

Thank you for your attention

summary DOC R&D PWN(T) 2018

G.Galjaard, PWNT

November 2018, Plymouth

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