

Constructed wetlands targeting nutrient removal in agricultural drainage discharge: A new cost-effective mitigation strategy in Denmark

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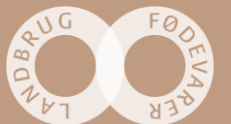
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SEGES

LuWQ 2019, Agriculture and Environment, Aarhus, Denmark

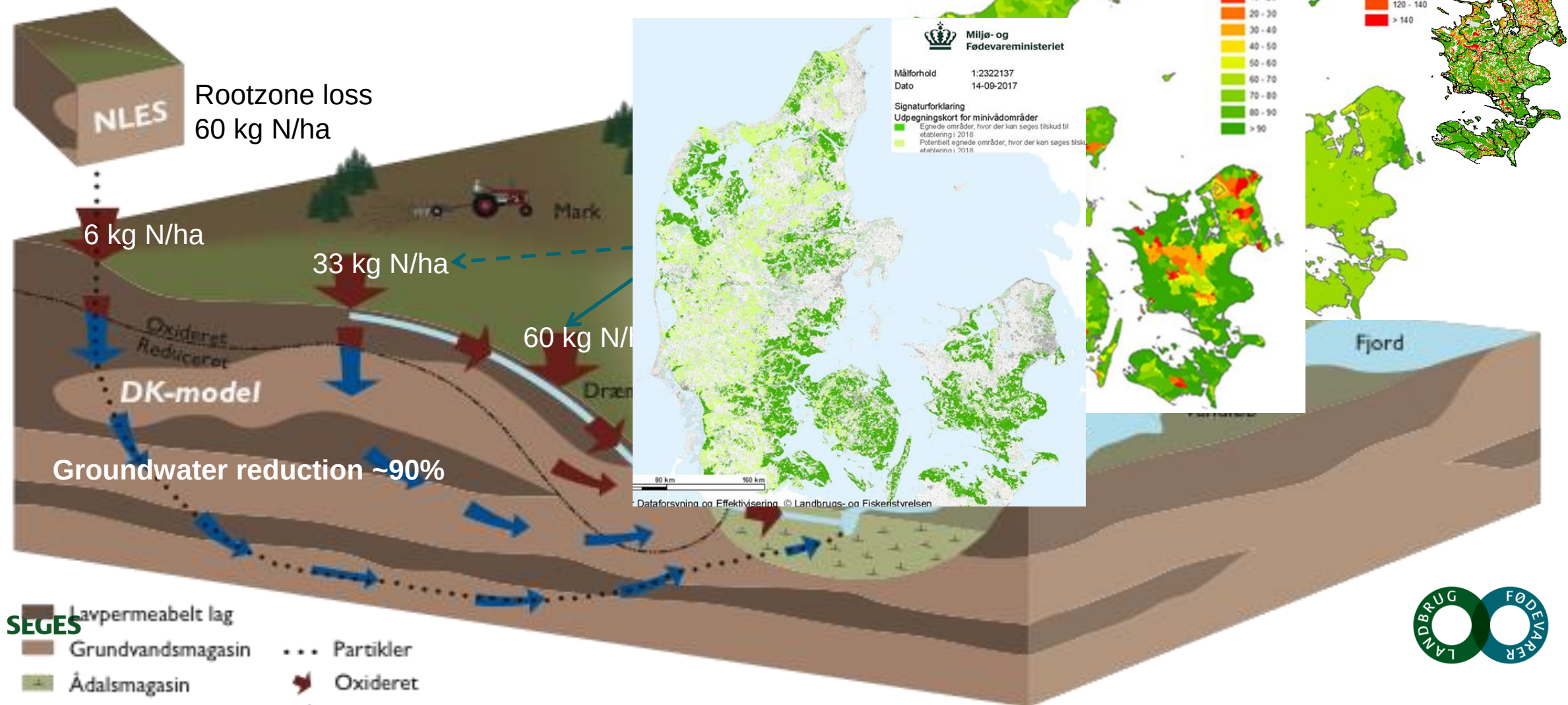
Promilleafgiftsfonden for landbrug



Drainage filters a new targeted mitigation strategy

Drainage losses of nutrients accounts nationally for:

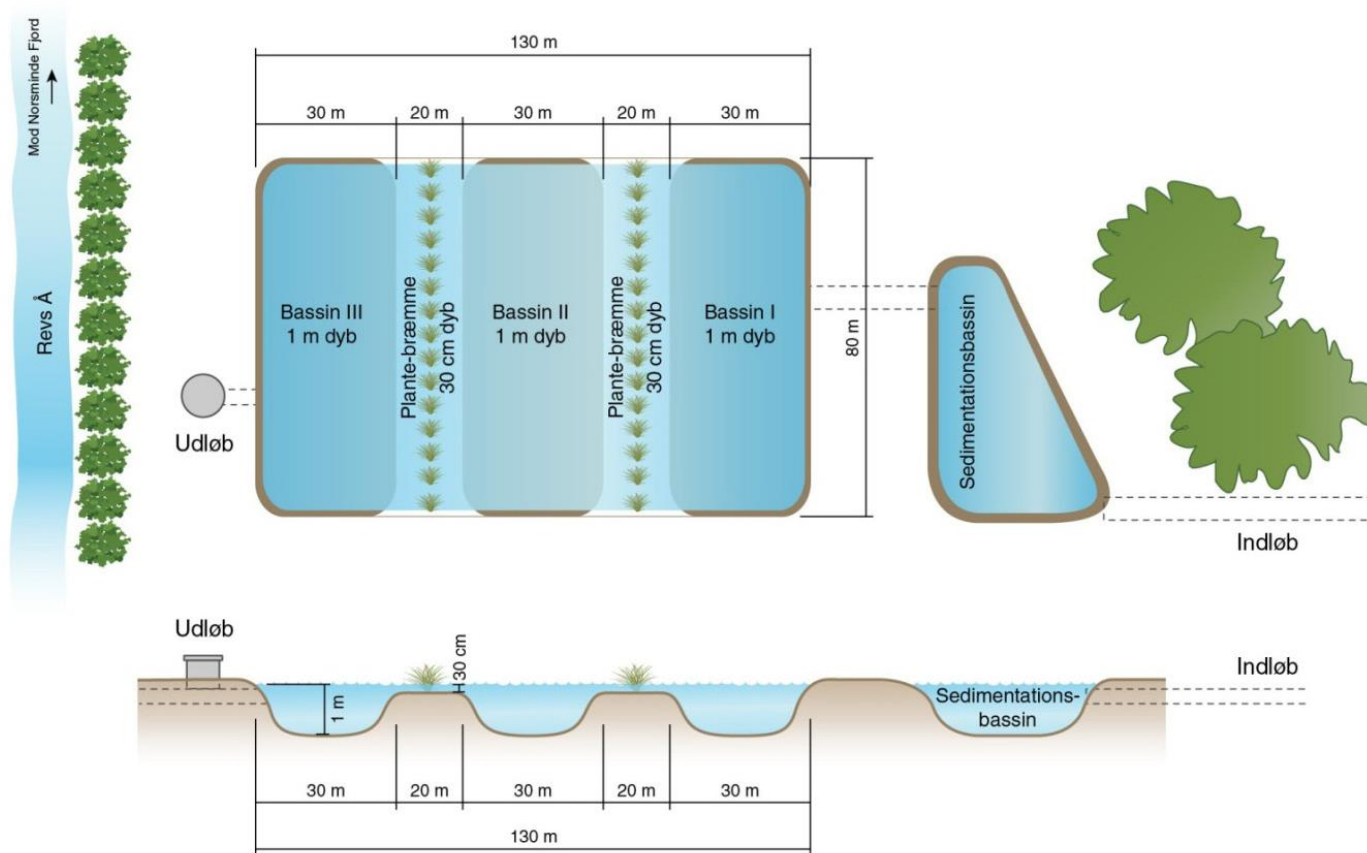
- 50-60% of agricultural N losses -> locally up
- Aprox. 33% of agricultural P losses



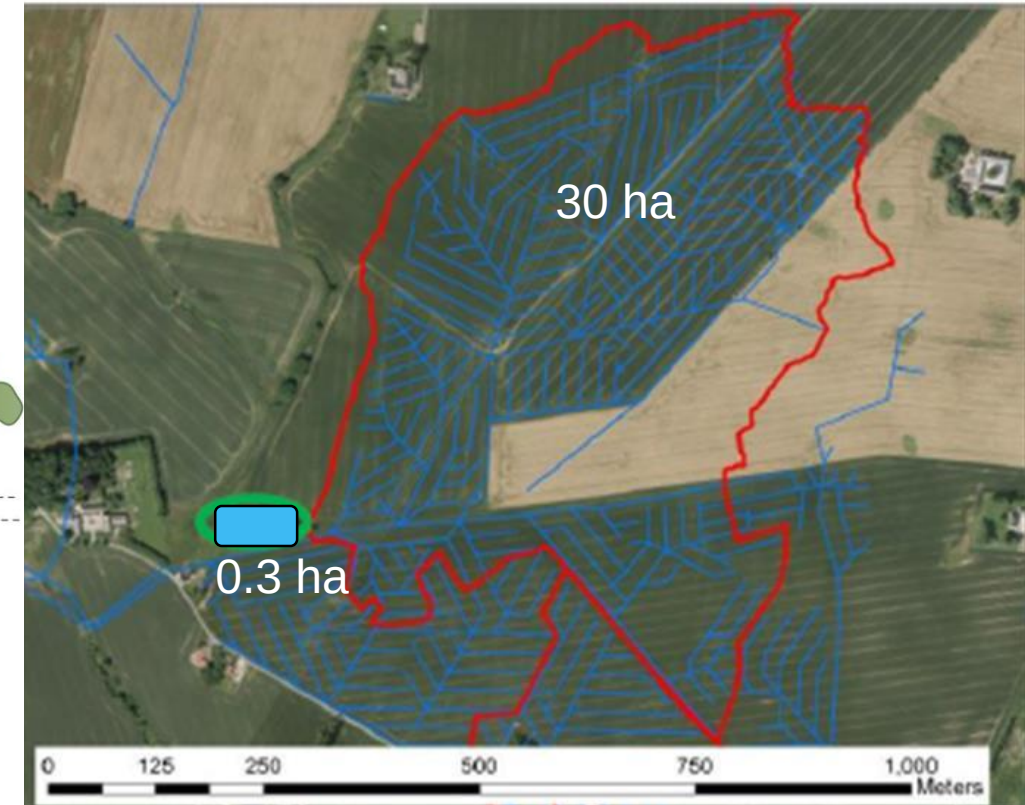
Drainage filters a new targeted mitigation strategy

Surface-flow constructed wetlands (SF-CW) – one of several drainage filter technologies

Size: 1% of the drainage catchment area



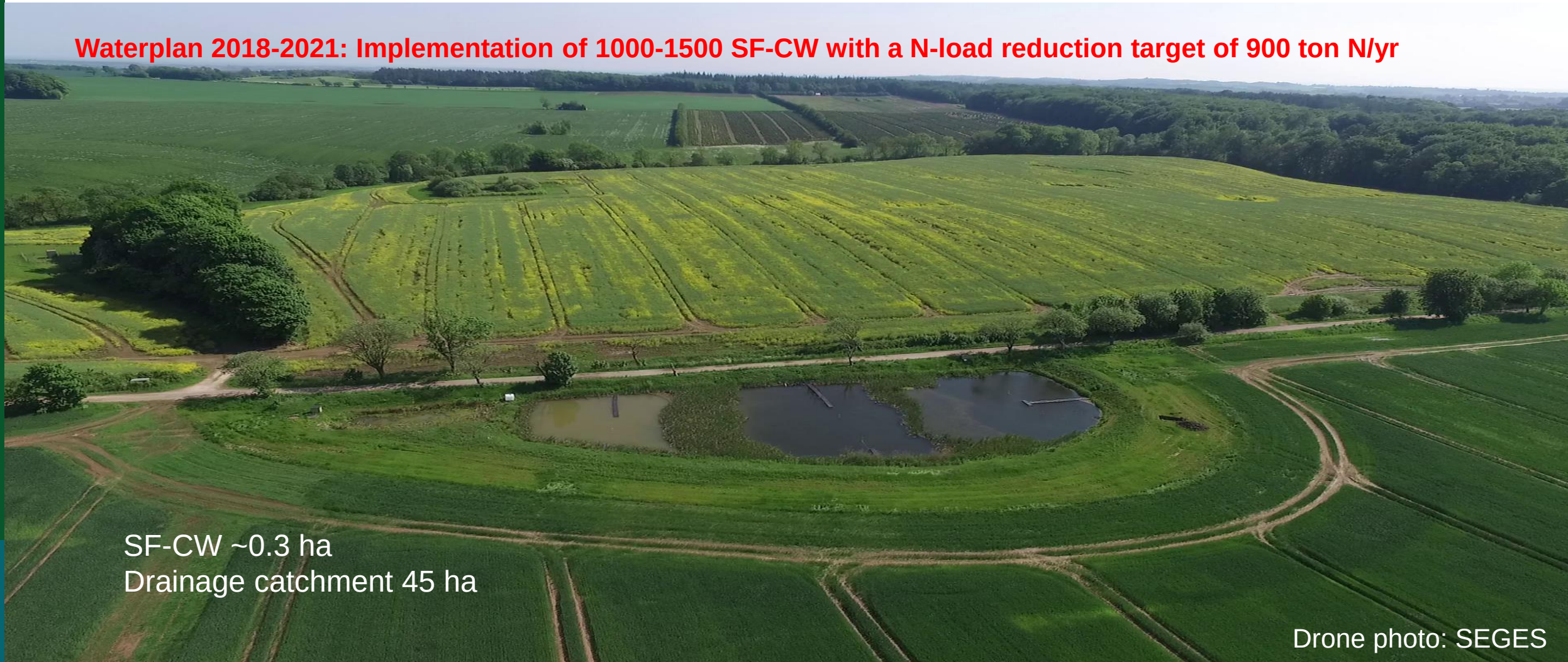
Deliniated drainage catchment



The first Danish surface-flow constructed wetland – Fillerup

Constructed in 2010 in the Norsminde Fjord Catchment, Odder, Denmark by DLMO, SEGES, AU

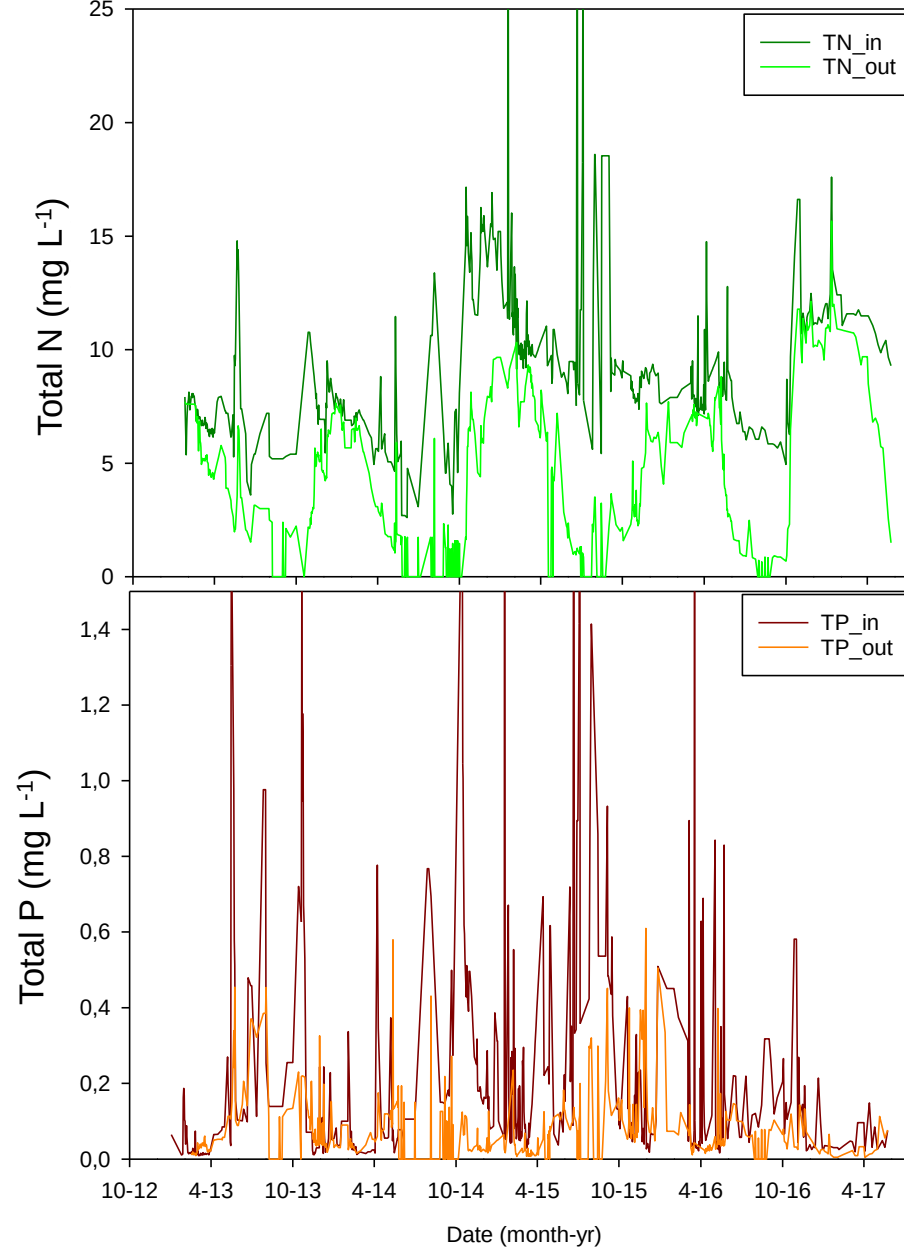
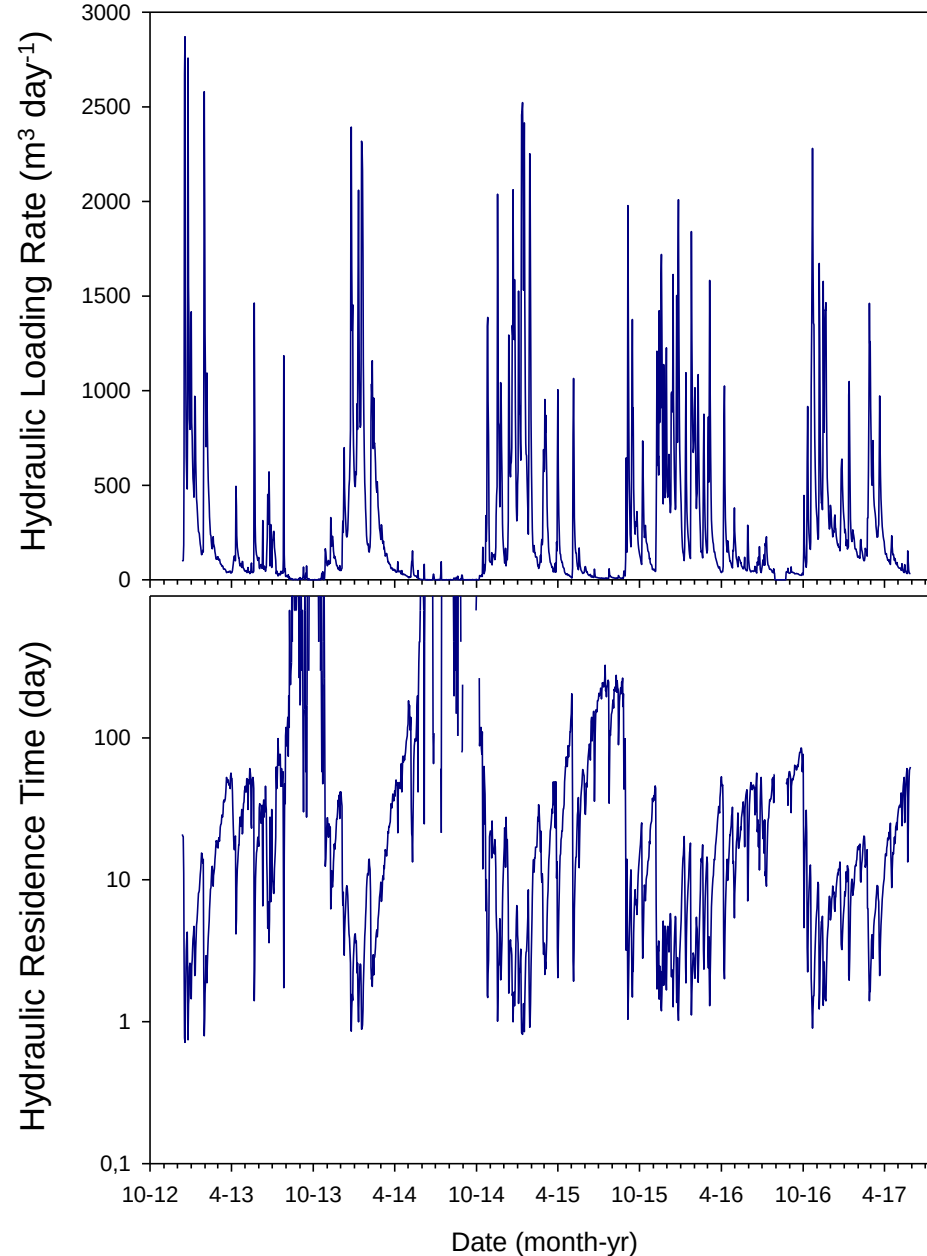
Waterplan 2018-2021: Implementation of 1000-1500 SF-CW with a N-load reduction target of 900 ton N/yr



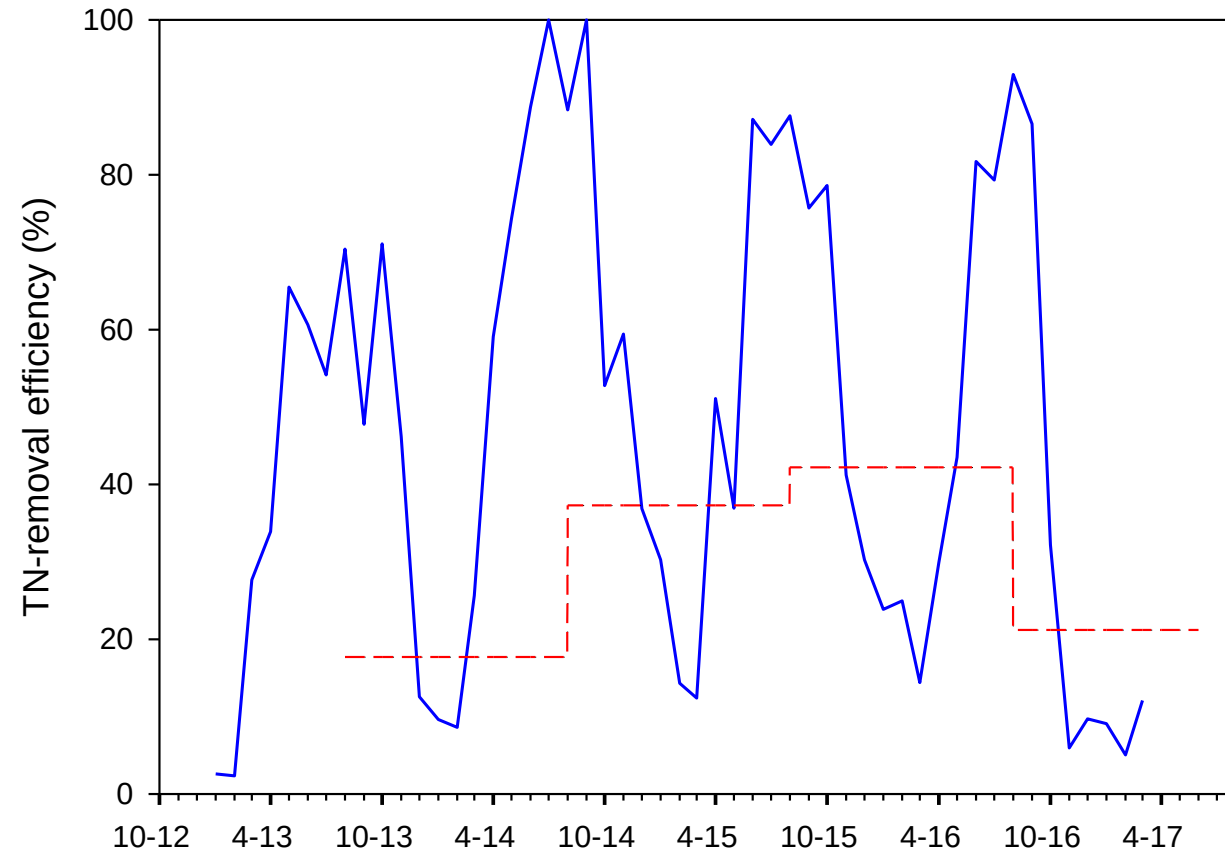
SF-CW ~0.3 ha
Drainage catchment 45 ha

Drone photo: SEGES

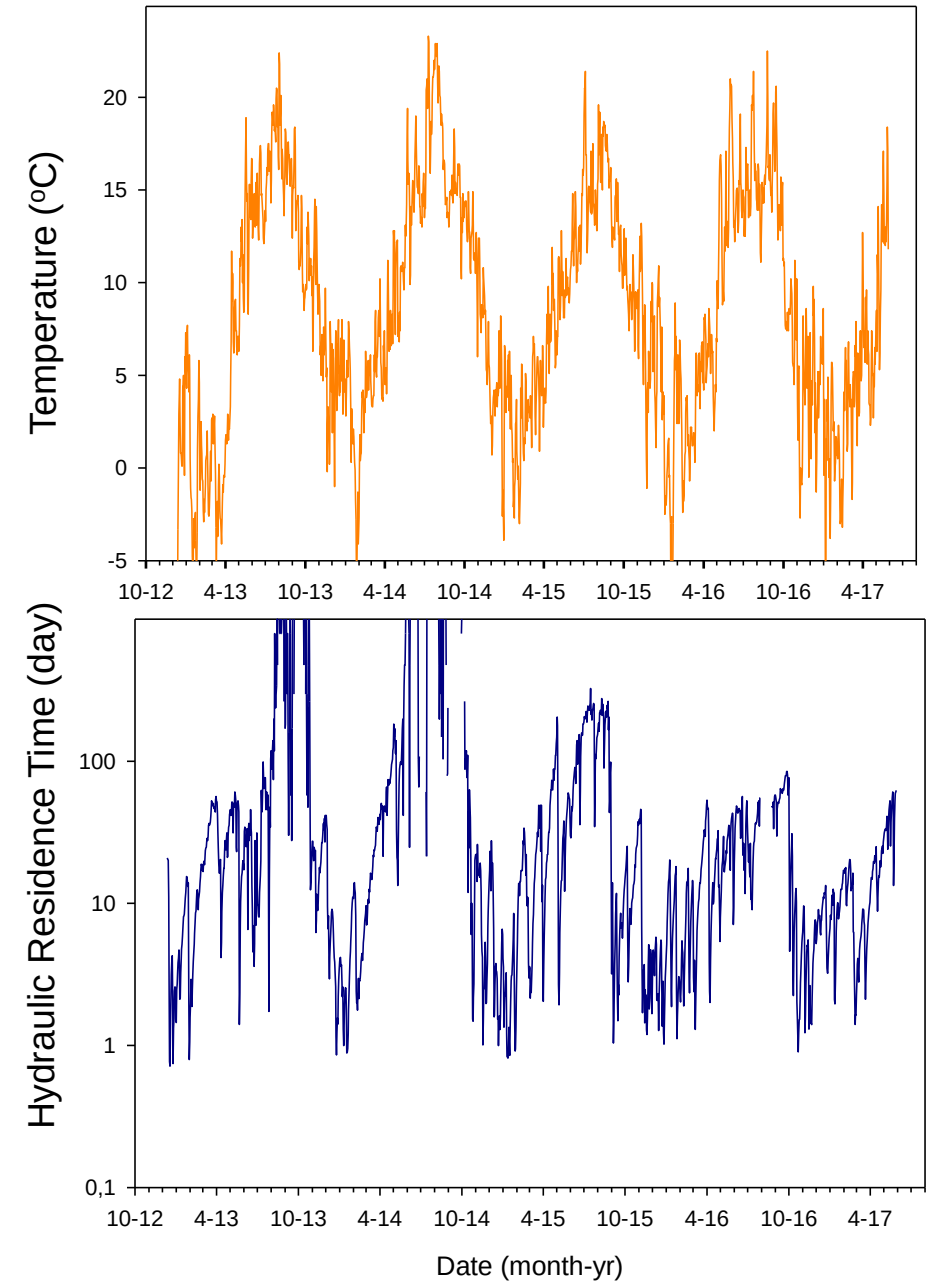
Nutrient retention in surface-flow constructed wetlands



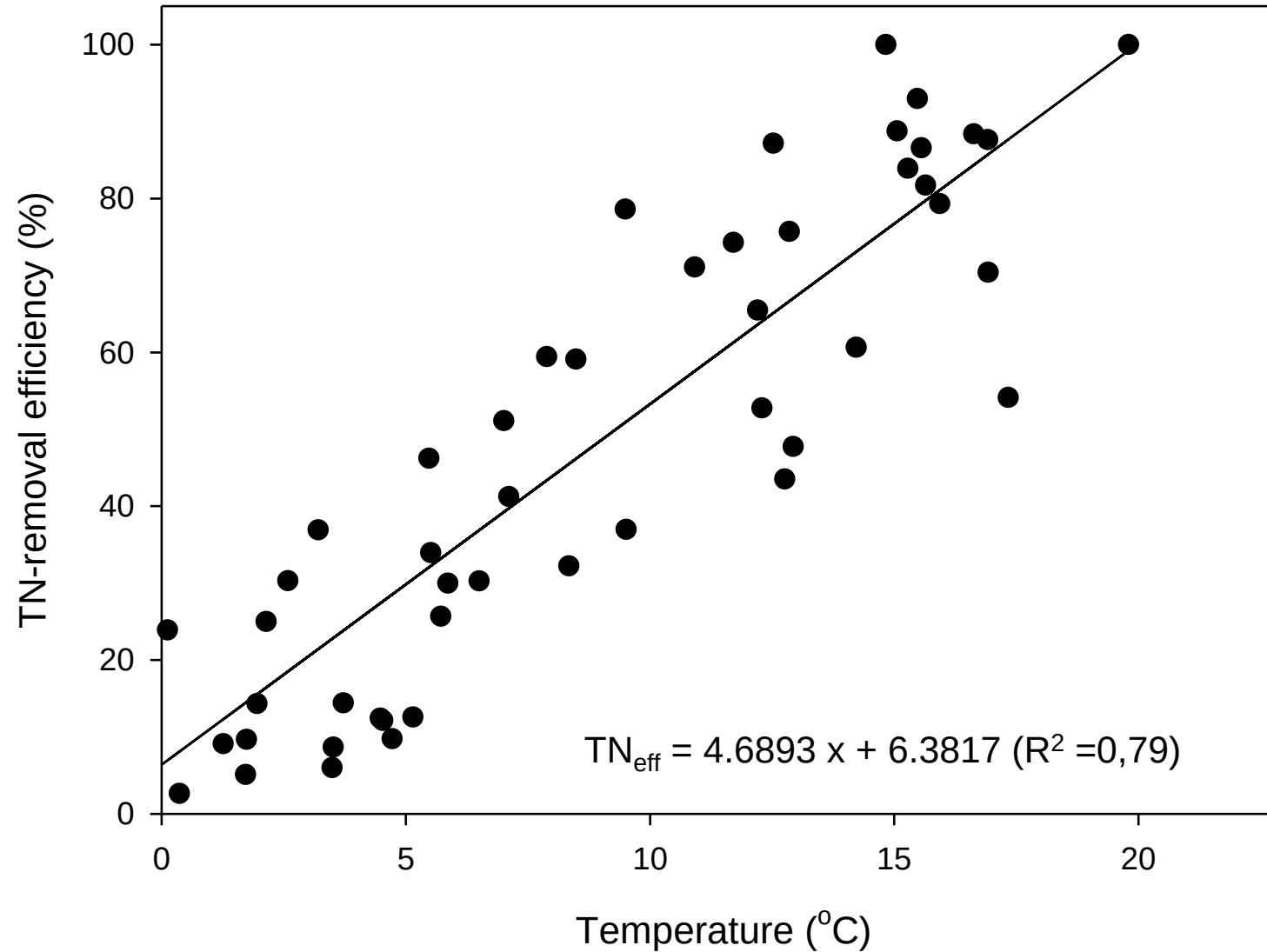
Seasonal and annual variation in N-removal efficiency



Red dotted line is the yearly average in the four years

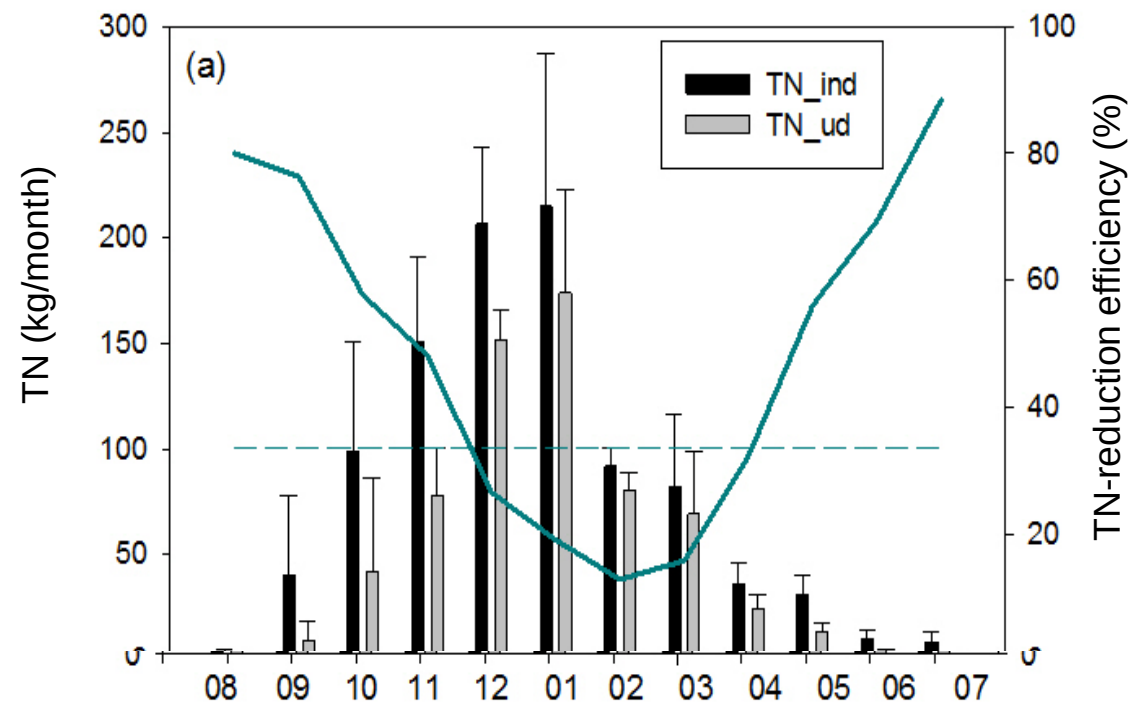


Temperature is the major controlling parameter for TN_{eff}

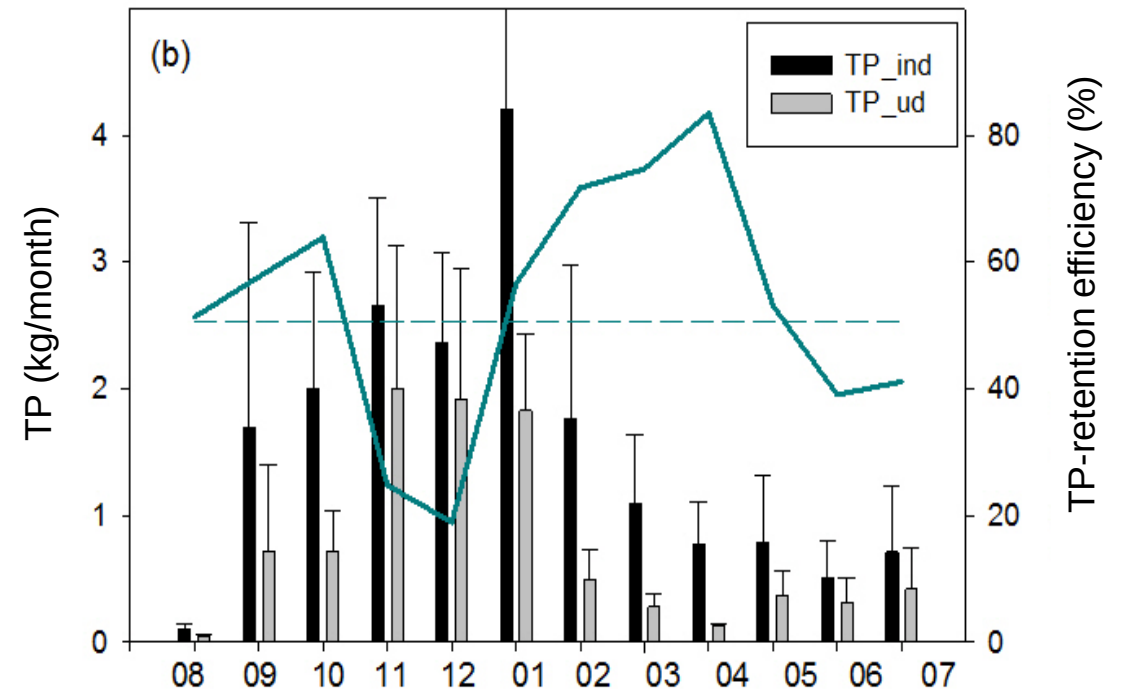


Effect of constructed wetland on drainage losses of N and P

Mass balance of monthly TN/TP inlet and outlet from the Fillerup SF-CW – average for years 2013-2017



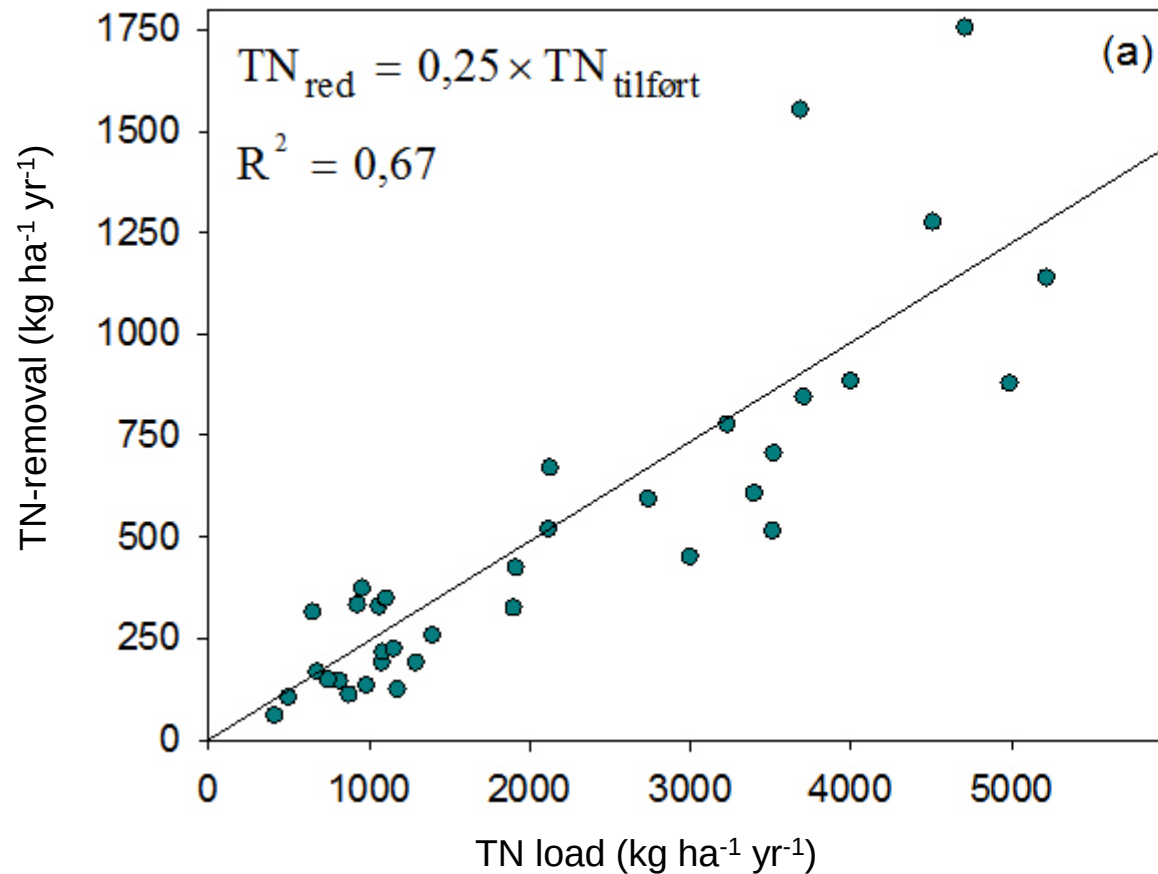
Average TN-reduction efficiency (2013-2017)
~35% N removal



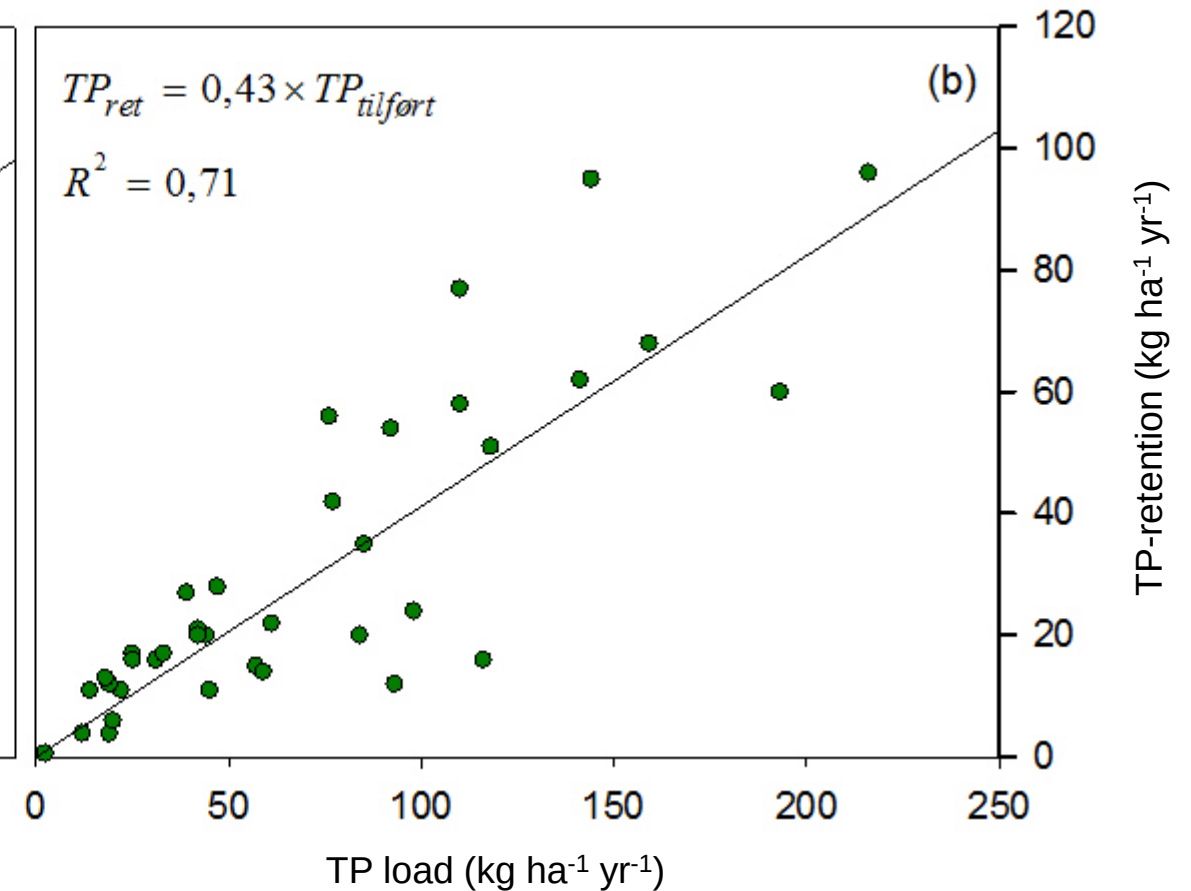
Average TP-retention efficiency (2013-2017)
~53% P retention

Overall results of Danish constructed wetlands (2013-2017)

TN-reduction average 25%



TP-retention average 43%



SEGES

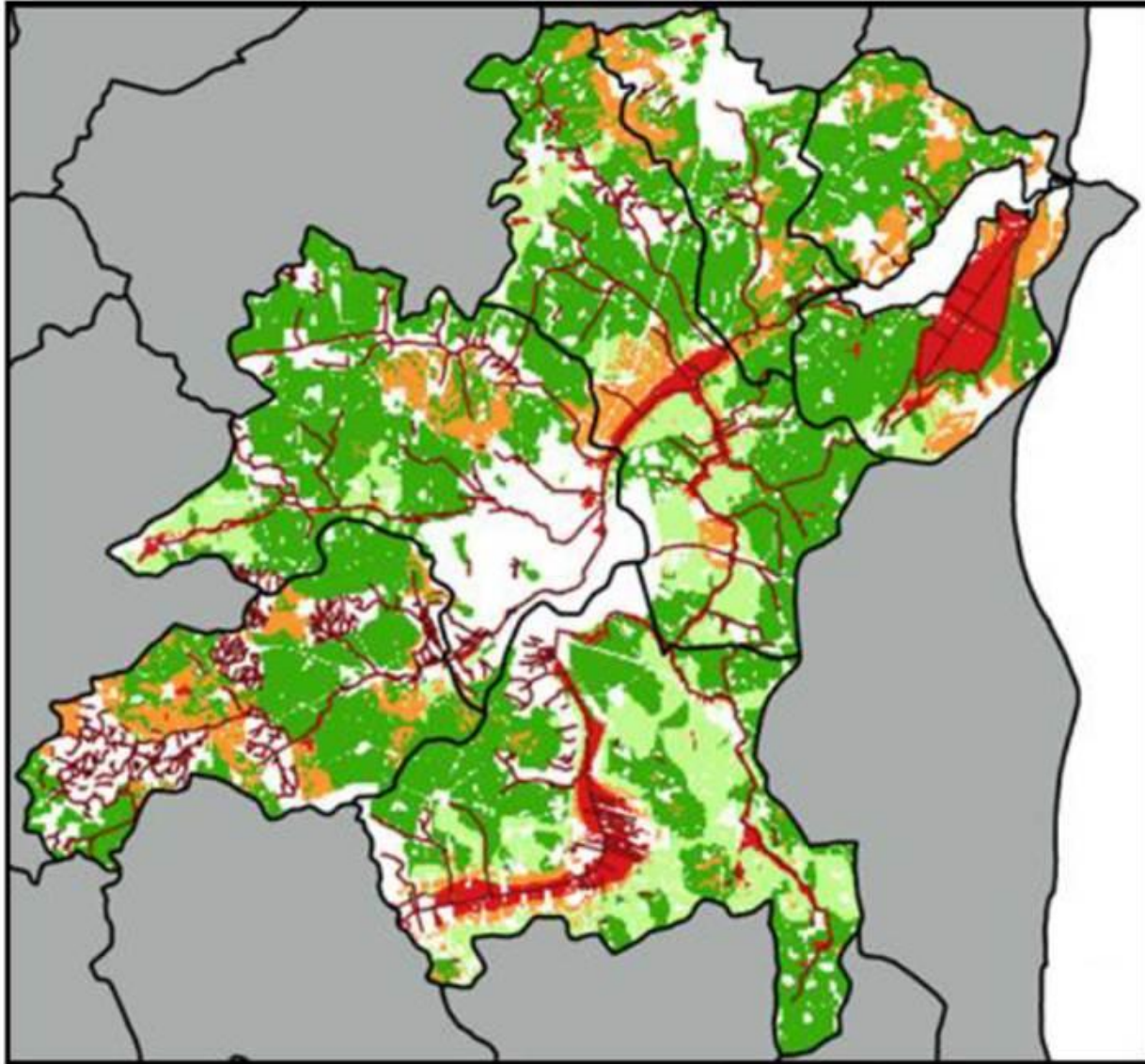
Controlling parameters (N):

- Temperature, (HRT) (*Kjaergaard et al., In prep*)
- Nitrate-N reduction in the anaerobic sediment

Controlling parameters (P):

- PLR, HLR, P-form, Fe:P-ratio (*Mendes et al, 2018*)
- P-stability (*Mendes et al., 2018*)

Mitigation strategy – Norsminde Fjord catchment



Catchment (10.100 ha) including six ID15 subcatchments (1500 ha units)

ID15 subcatchment	Suitable for CWS (%)	Upland drained to riparian lowland (%)	Riparian lowland (%)
43600028	61	4,4	16
43600041	50	33	11
43600042	75	11	2,5
43600043	61	22	6,2
43600051	73	1,1	0,9
43602599	72	5,4	1,1
Total	4.815 (63)	1.224 (16)	541 (7)

Kjærgaard, C., Hoffmann, C.C., Iversen, B.V. 2017. Filtre i landskabet øger retentionen. I: Filtre i landskabet, Vand & Jord, nr. 3, s. 106-110

Mitigation strategy – Norsminde Fjord catchment

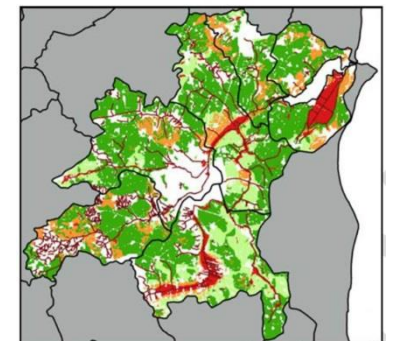
Subcatchment (ID15) N-reduction target in 2021 = 2.594 kg N/yr

- Calculations conducted for a ID15 subcatchment (1500 ha) with 70% agricultural area (1050 ha)
- Average N-leaching from rootzone ~60 kg N/ha and average N-retention is 62%

Mitigation measure	N-reduction target (kg N/yr)	N-effect rootzone (kg N/ha/yr)	N-effect on coastal load (kg N/ha/yr)	Required area of measure (ha)	Cost of measure (€/ha/yr)	Cost of mitigation strategy (ID15) €/yr
Catch crops	2.594	30	11.4	228	94	21.319
Set-aside	2.594	50	19.0	137	535	73.092
SF-CW	2.594	14	6.75	3.84	87*	33.433
Bioreactor	2.594	27	13.5	0.38	51**	9.773

*Construction cost depreciation in 10 years

** Constuction cost depreciation in 5 years (not including new supply of woodchips)



Conclusions and perspectives

- Constructed wetlands (surface-flow CWs and subsurface-flow bioreactors) are cost-effective targeted measures, which allow achievement of catchment/subcatchment nutrient reduction targets using very little landarea
- Long-term P-retention depends on the stability of accumulated P (Mendes et al., 2018), or the removal of potential P sources
- N-removal efficiencies are limited during winter discharge (temperature limitation) – new solutions are investigated



Innovation Platform for Drainage Filter Technologies

Promilleafgiftsfonden for Landbrug

Photo: Charlotte Kjærgaard

A photograph of a wetland area. In the foreground and middle ground, there are numerous yellow iris flowers with long green leaves growing out of the water. The water is calm and reflects the sky and the plants. In the background, there is a line of green trees under a clear blue sky. On the right side of the image, a dog with white and brown fur is standing on the grassy bank, looking towards the water.

Thank you for your attention

Funding projects ~10 mio US \$

- SupremeTech (www.supremetech.dk), 2010-2016, Danish Strategic Research Council
- iDRAIN (www.idrain.dk), 2011-2017, GUDP
- SF-CWs, 2013-2017, MFVM, Environmental Technology Fund

Photo: Carsten Søbog