

SMALL & SMART

Real time control of the SBR process for the treatment of variable wastewater, using robust and low-cost online sensors

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Content

- The problem
- A potential solution
- Back in the “old days”
- Conclusion

The Tank-Truck Cleaning case



Sludge toxicity

Discharge limits (COD)

ECO-toxicity

Variability

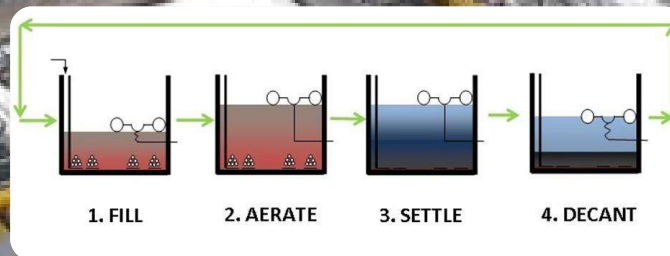
Problem n°1 = variable wastewater

Composition of pre-treated TTC wastewater

	Min.	Max.	Avg. \pm SD	% CV
COD (mg/L)	1024	3000	2078 \pm 409	20
NH ₄ -N (mg/L)	57	194	115 \pm 30	26
COD/N (-)	9	33	19 \pm 5	28

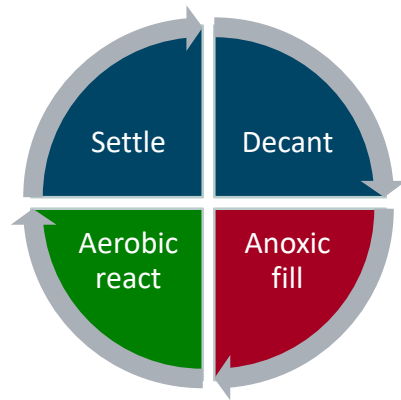
5

Problem n°2 = fixed SBR cycle



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The solution = **dynamic** process



Anoxic fill phase:

- denitrification
- ORP profile (pH)

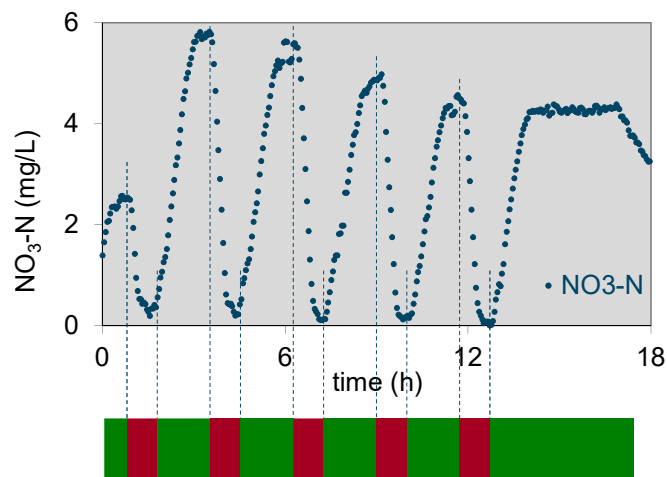
Aerobic react phase:

- COD oxidation
- nitrification
- OUR profile

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Anoxic phase control in a step-feed SBR



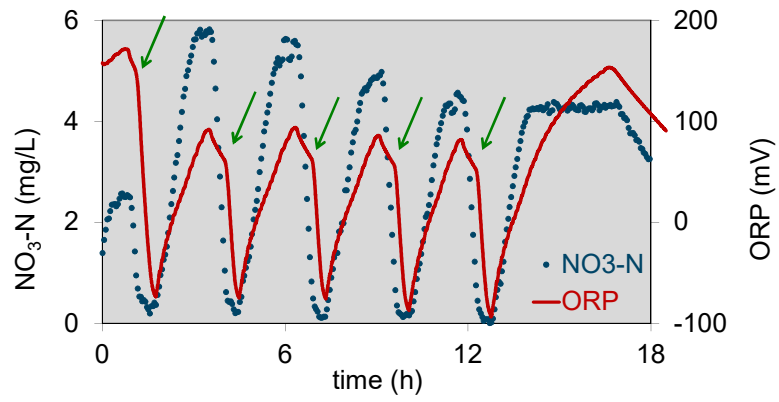
Anoxic
fill

Aerobic
react

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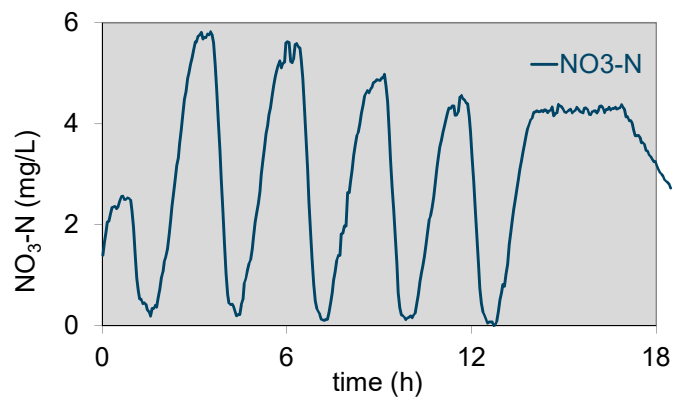
Anoxic phase control: **ORP knee**



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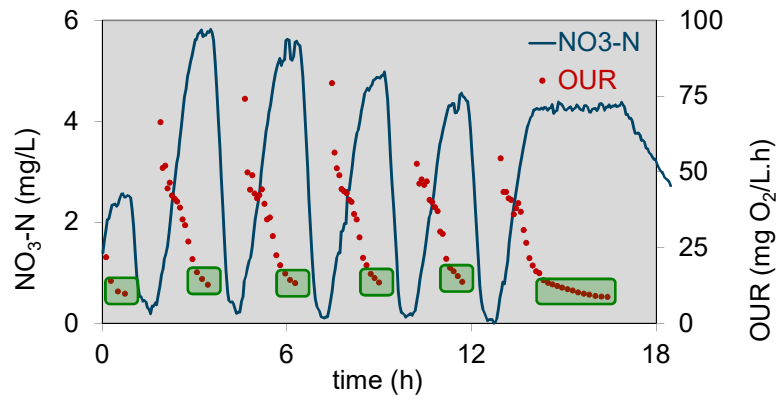
Aerobic phase control



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Aerobic phase control: **low & constant OUR**



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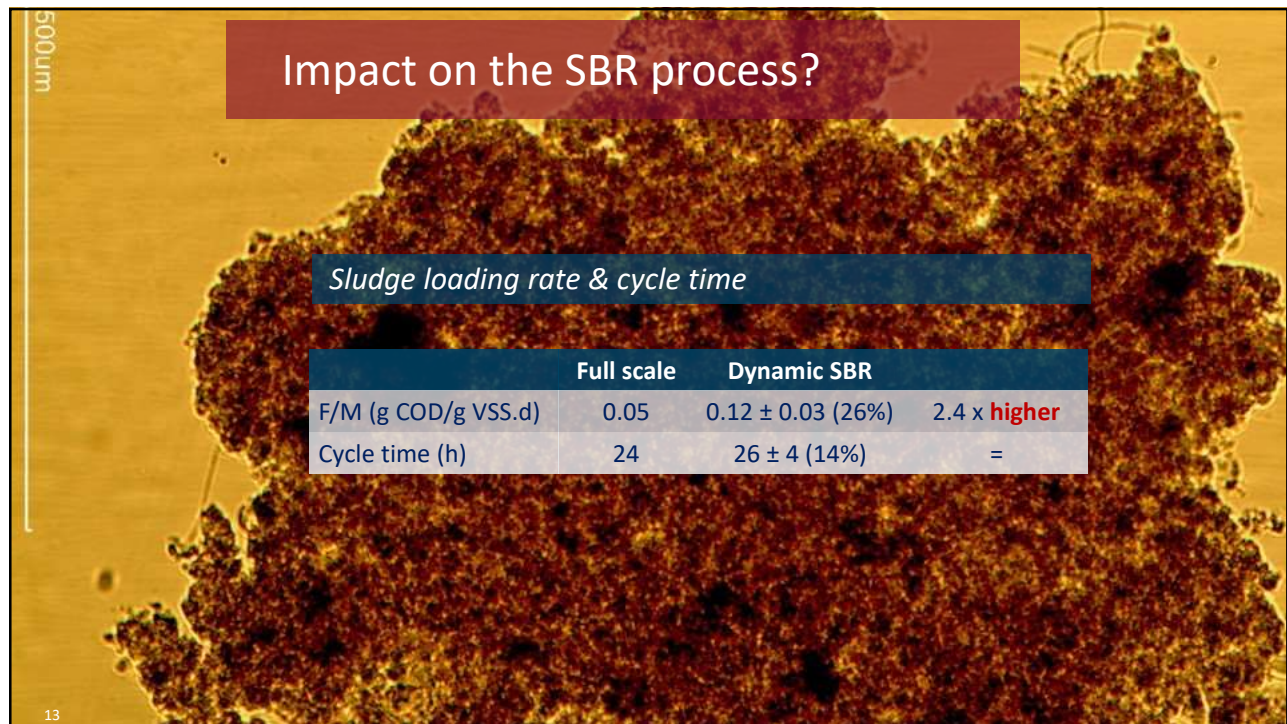


Impact on effluent quality?

COD & N in the effluent

	Min.	Max.	Avg. ± SD
COD (mg/L)	63	283	153 ± 50
NH ₄ -N (mg/L)	0.8	7.2	3 ± 1
NO ₃ -N (mg/L)	0.7	4.2	2 ± 1

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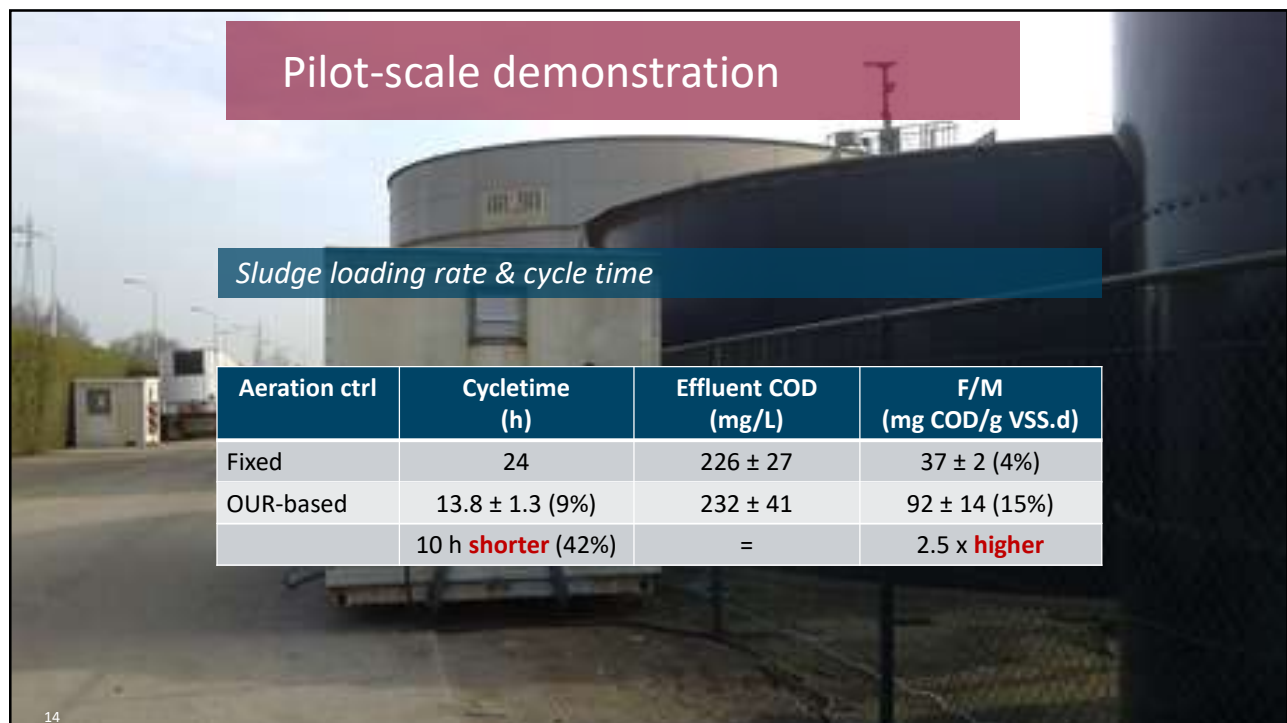
500µm

Impact on the SBR process?

Sludge loading rate & cycle time

	Full scale	Dynamic SBR	
F/M (g COD/g VSS.d)	0.05	0.12 ± 0.03 (26%)	2.4 x higher
Cycle time (h)	24	26 ± 4 (14%)	=

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Pilot-scale demonstration

Sludge loading rate & cycle time

Aeration ctrl	Cycletime (h)	Effluent COD (mg/L)	F/M (mg COD/g VSS.d)
Fixed	24	226 ± 27	37 ± 2 (4%)
OUR-based	13.8 ± 1.3 (9%)	232 ± 41	92 ± 14 (15%)
	10 h shorter (42%)	=	2.5 x higher

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Conclusions, *part 1*

Simple *rule-based* control strategy using robust sensors

SBR cycle with variable length, depending on

- characteristics of the wastewater
- activity of the micro-organisms

But...

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This sounds like... old?!

1983

ORP REGULATION AND ACTIVATED SLUDGE: 15 YEARS OF EXPERIENCE

Joseph Charpentier*, Guy Martin**, Hervé Wacheux*** and Pierre Gilles† *Wat. Sci. Tech.* Vol. 38, No. 3, pp. 197–208, 1998.

In order to complete and support the industrial application of ORP regulation for Activated Sludge, initiated by the first installation at Yffiniac in 1983,

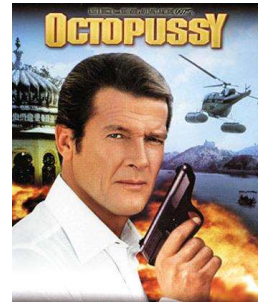
1987

OXIDATION-REDUCTION POTENTIAL (ORP) REGULATION: A WAY TO OPTIMIZE POLLUTION REMOVAL AND ENERGY SAVINGS IN THE LOW LOAD ACTIVATED SLUDGE PROCESS

Wat. Sci. Tech. Vol. 19, Rio, pp. 645–655, 1987.

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Images of 1983



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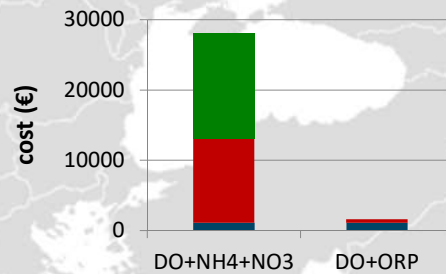
Conclusions, *part 2*

400 industrial AS systems
48% SME
64% BNR

23% has energy data

35% SBR

96% equipped with DO
< 10% NO₃ and/or NH₄



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More info?



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- Real-time control:
Dries (2016) WST 73: 740-745
- Ecotoxicity in industrial effluents:
Caluwé *et al.* (2018) Environmental Technology 39: 2524-2533
- Industrial WWTP survey in Flanders:
Cornelissen *et al.* (2018) WST 78: 957-967

