LIFE DeNTreat

Decentralized innovative treatment of ammonium-rich urban wastewater

Keynote on anammox based processes

Anuska Mosquera Corral

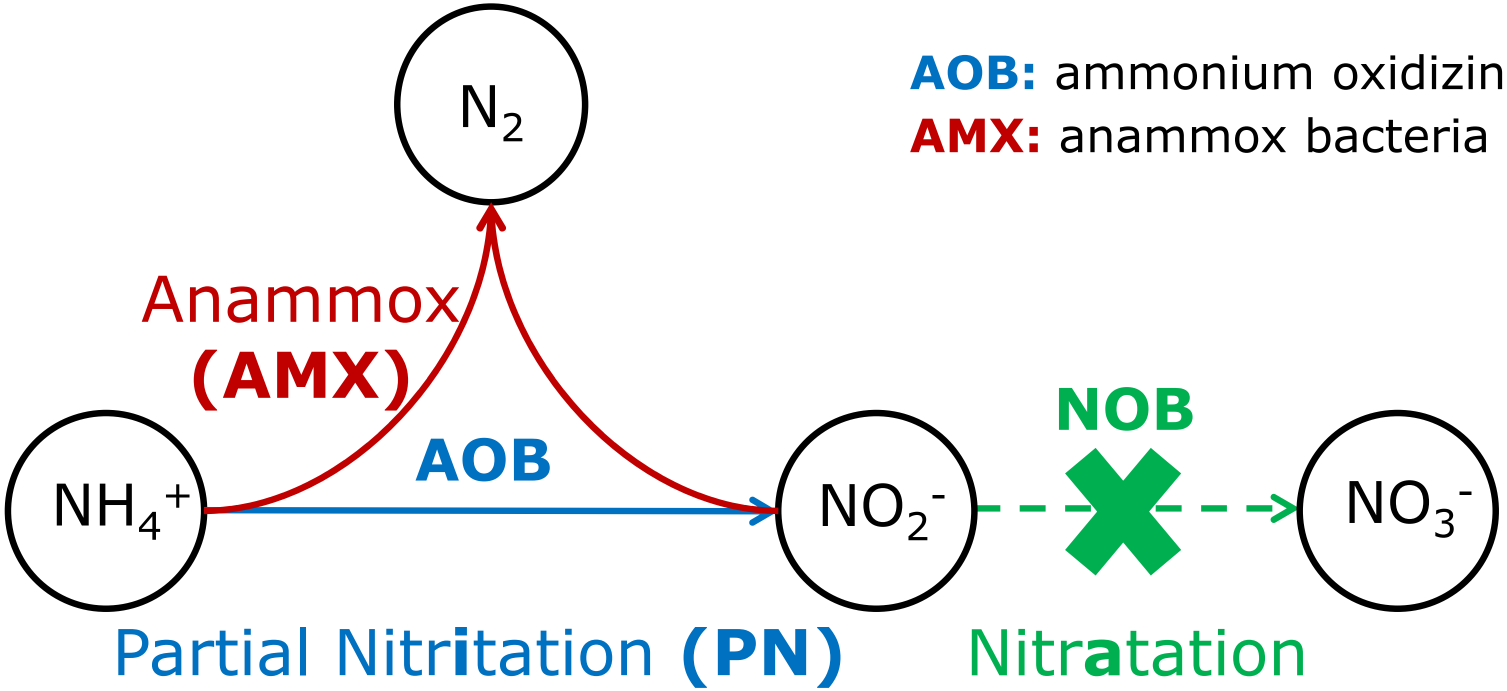
Universidade de Santiago de Compostela, Spain

LIFE DeNTreat FINAL EVENT – web meeting

February 24th, 2021

The project has received funding from European Union´s LIFE Programme under Grant Agreement LIFE16 ENV/IT/000345

Nitrogen is autotrophically removed by the combination of partial nitritation-anammox processes (PN/AMX)

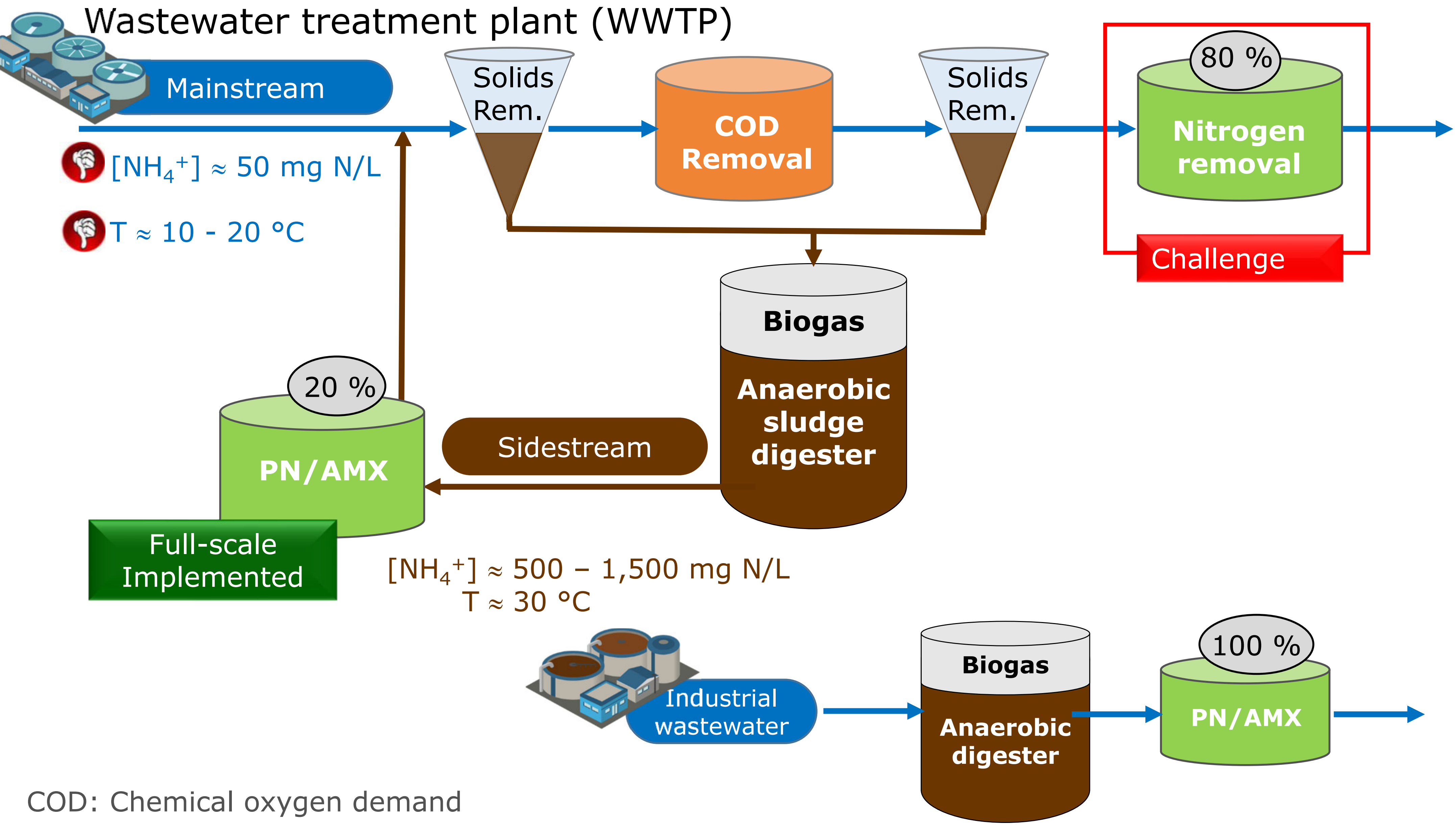


AOB: ammonium oxidizing bacteria
AMX: anammox bacteria

Compared to nitrification-denitrification processes:

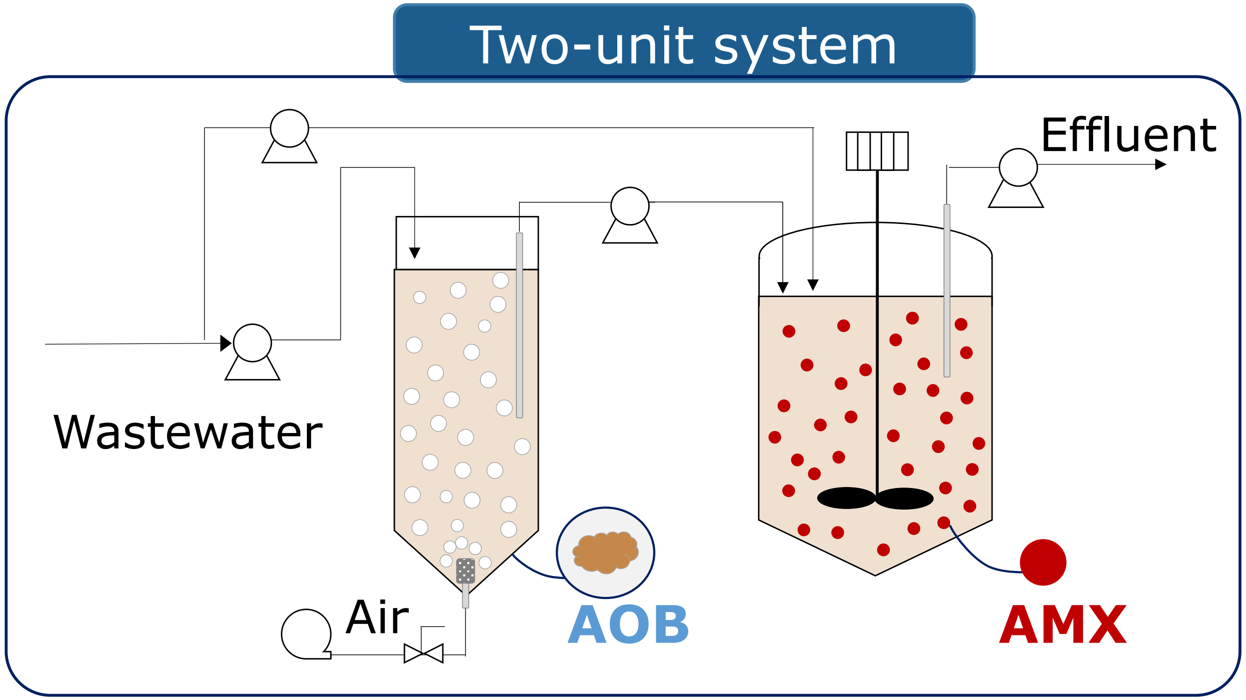
- Less energy for aeration
- Less sludge production
- Organic matter saved for biogas production

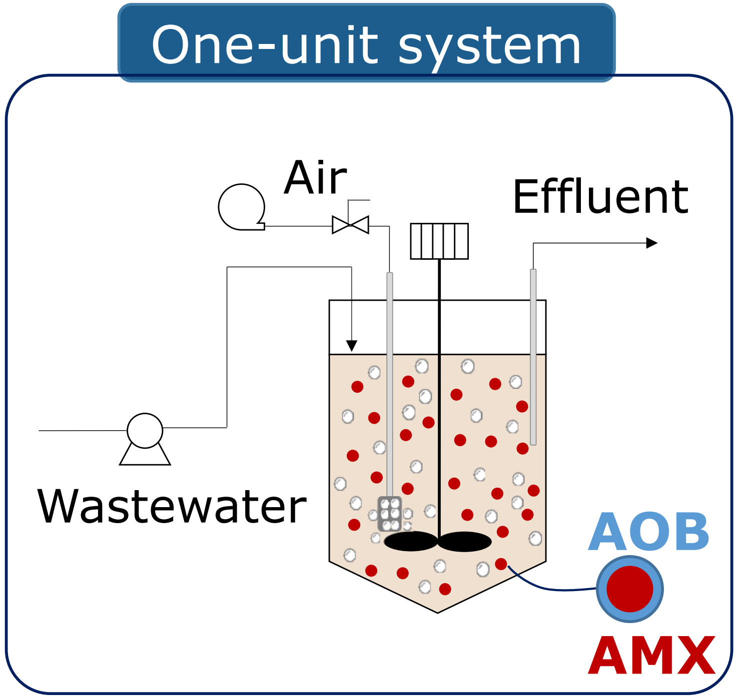
PN/AMX processes have different potential to remove nitrogen from mainstream or sidestream



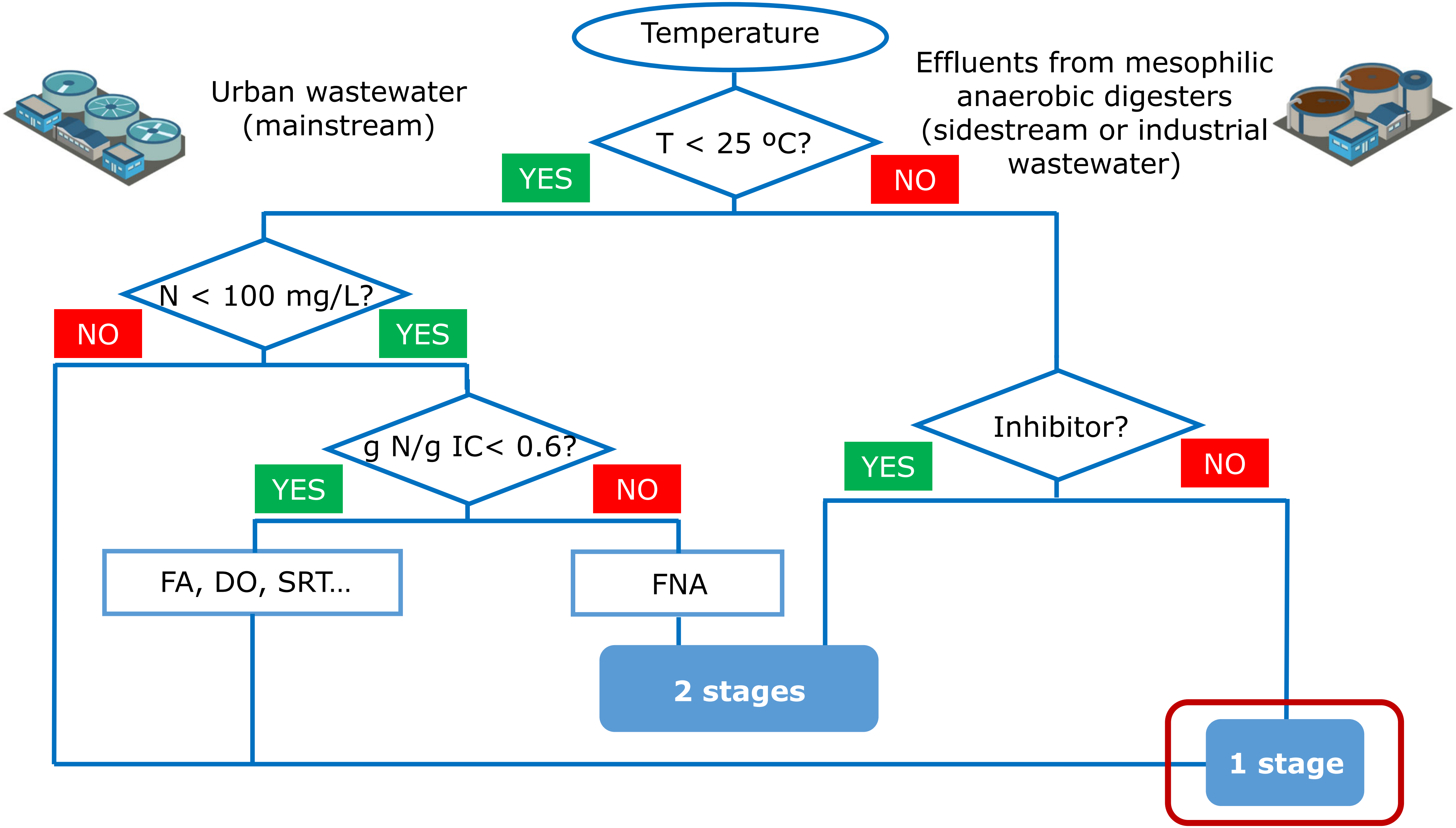
COD: Chemical oxygen demand

Nitritation and anammox processes occur in different reactor configurations

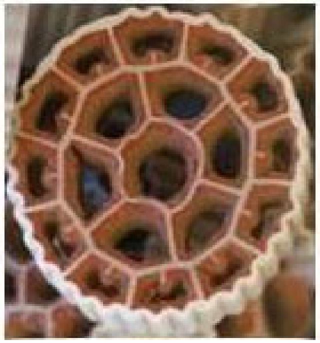
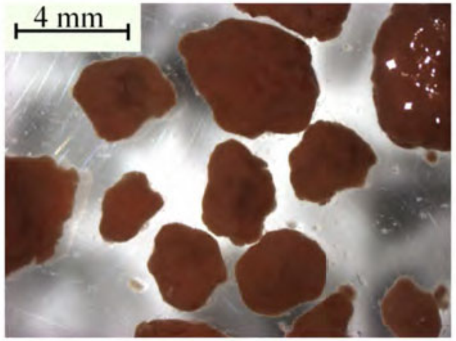
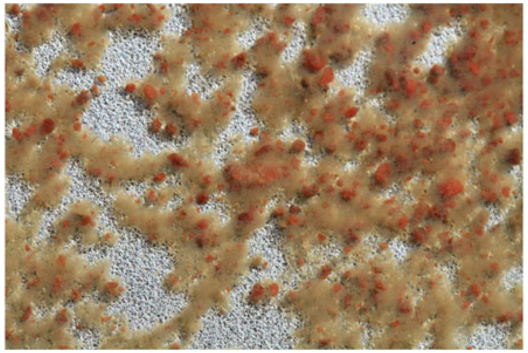




Selection of reactors configuration for PN/AMX



One-unit technologies based on biofilm biomass are more common

	MBBR/IFAS	Granules	Granules+flocs
			
	ANITA™MOX	**ELAN®**	**DEMON®**
Carrier material	YES	NO	NO
Energy requirements	Aeration + mechanical stirring	Aeration	Aeration + cyclone
Control system	Intermittent aeration	Conductivity	pH and intermittent aeration
Solids separation	Specific unit	Same unit	Cyclones

One-stage system: Research at pilot scale was performed to validate the process (2010-2013) ELAN®

1.5 L

200 L

1,200 L

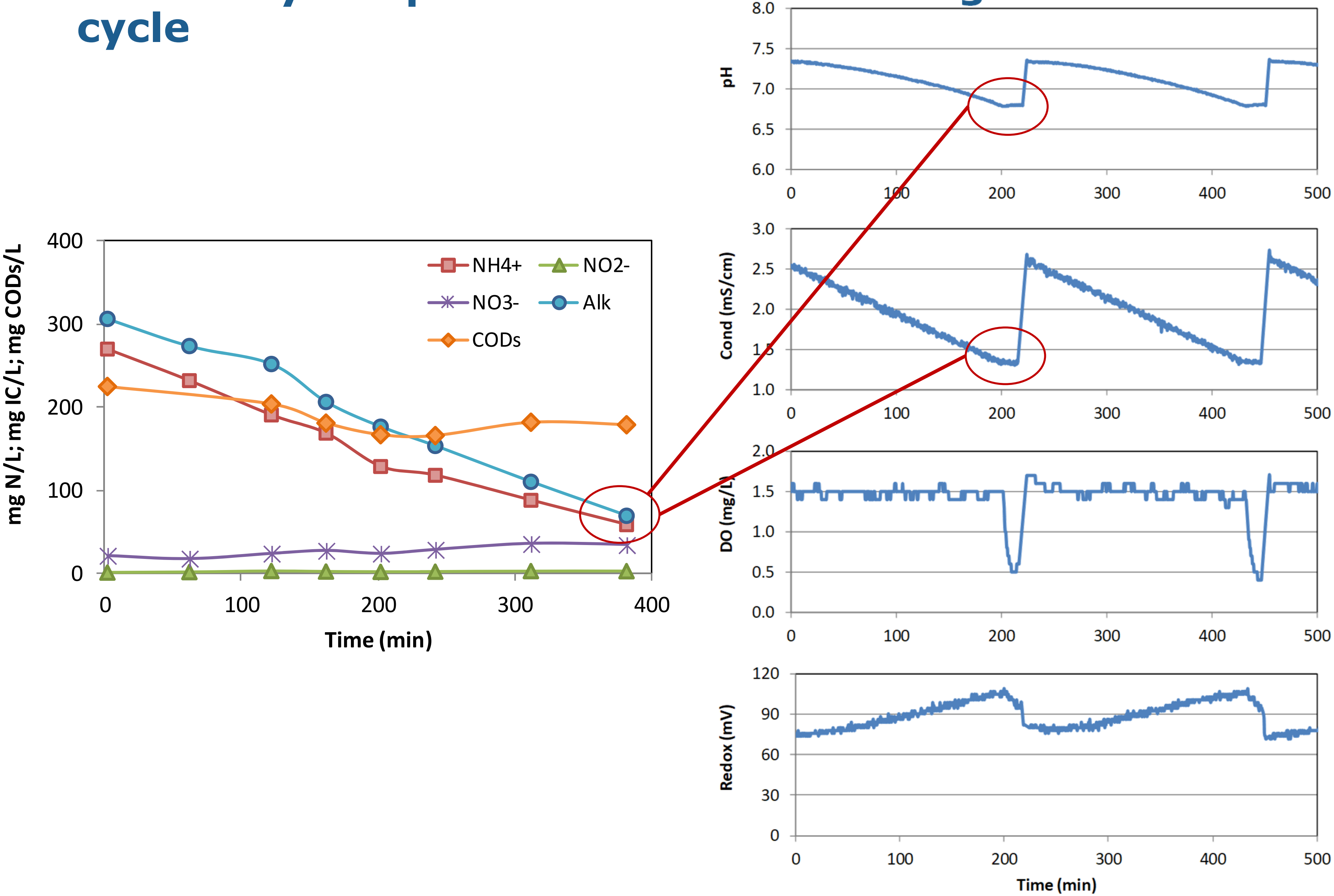
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

aqualia

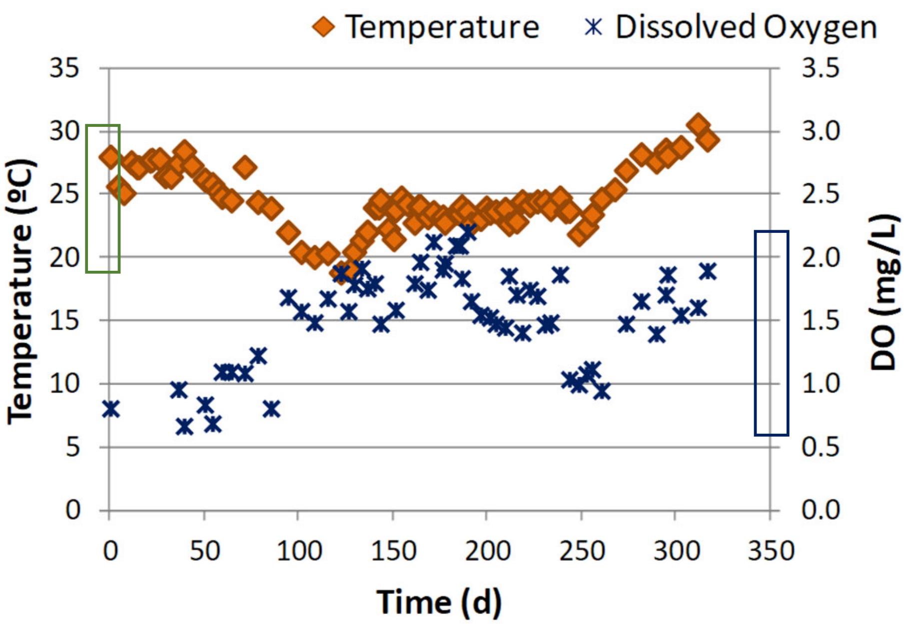
aqualia

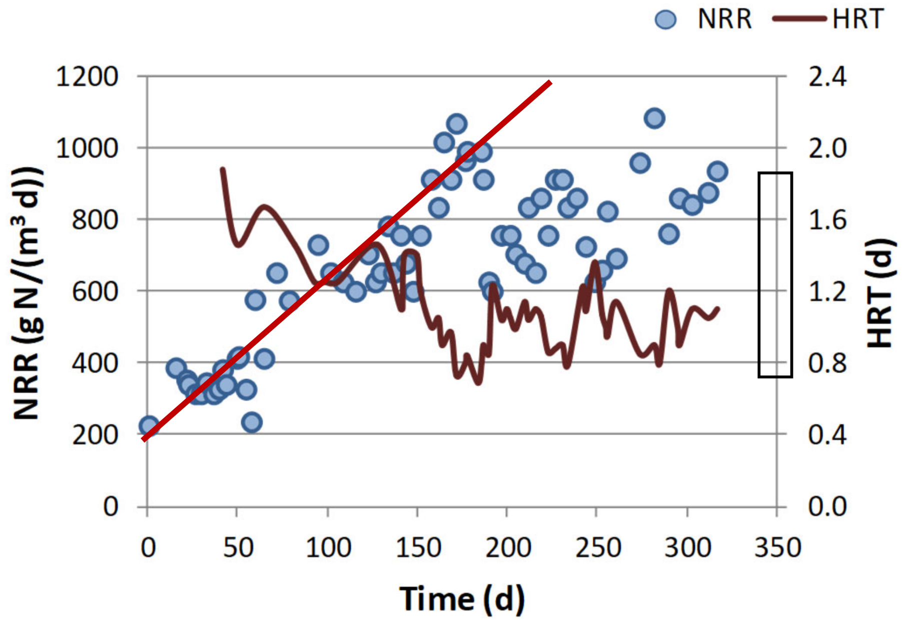
*ELAN® process (ELiminación Autótrofa de Nitrógeno): combination of partial nitrification and Anammox in a single reactor.

Conductivity set-point determines the length of the SBR cycle



SBR granular reactors were evaluated in Guillarei WWTP



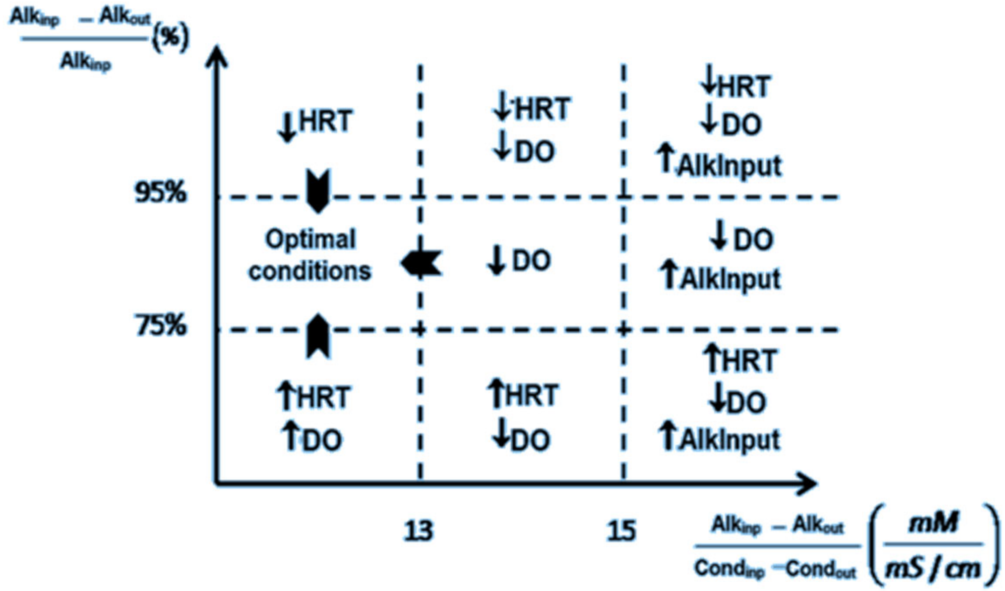


Nitrogen Compounds		
NH_4 influent	*mg N/L*	850 – 1500
NH_4 effluent	*mg N/L*	63 – 250
NO_2 effluent	*mg N/L*	1 – 5
NO_3 effluent	*mg N/L*	23 – 102
Average Nitrogen Removal		**82 %**
Biomass		
TSS	*g/L*	12.9
VSS	*g/L*	11.8
SVI	*mL/g TSS*	36

Vázquez-Padín et al., (2014) Water Science and Technology, 69(6), 1151-1158. Doi: 10.2166/wst.2013.795

The control of the ELAN® process is based on conductivity measurements

- Simple and robust control strategy
- HRT and Dissolved Oxygen concentration in the bulk liquid
- Following the "conductivity vs time slope" as method for reactor surveillance. (**European Patent: EP2740713**)



Parameter	**Nitrification-Denitrification**	**ELAN®**	**Saves (%)**
O_2 consumption (kg O_2/kg N)	3.18	**1.83**	**-42**
COD consumption (kg COD/kg N)	4.9	**0**	**-100**
CO_2 emission (kg CO_2/kg N)	3.52	**3.26**	**-7**
Biomass yield (kg VSS/kg N)	2.11	**0.12**	**-94**

Vázquez-Padín et al., (2014) Water Science and Technology, 69(6), 1151-1158. Doi: 10.2166/wst.2013.795

PN/AMX in one-unit systems: ELAN® process

25 m^3 activated sludge (3.5 g TSS/L) + 1.4 m^3 of anammox enriched sludge (10 g VSS/L)

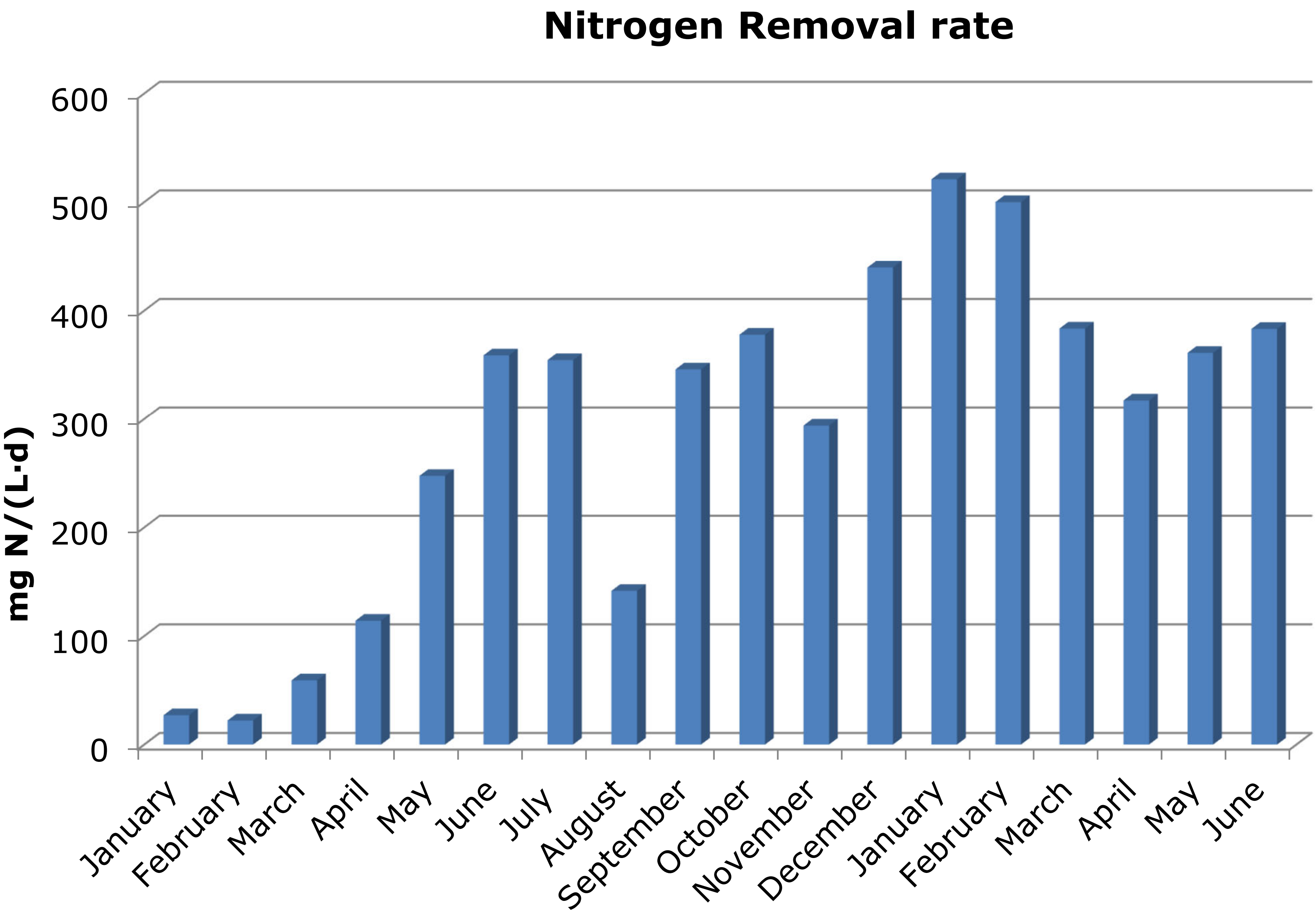
5 g VSS/L

Oxygen limitation

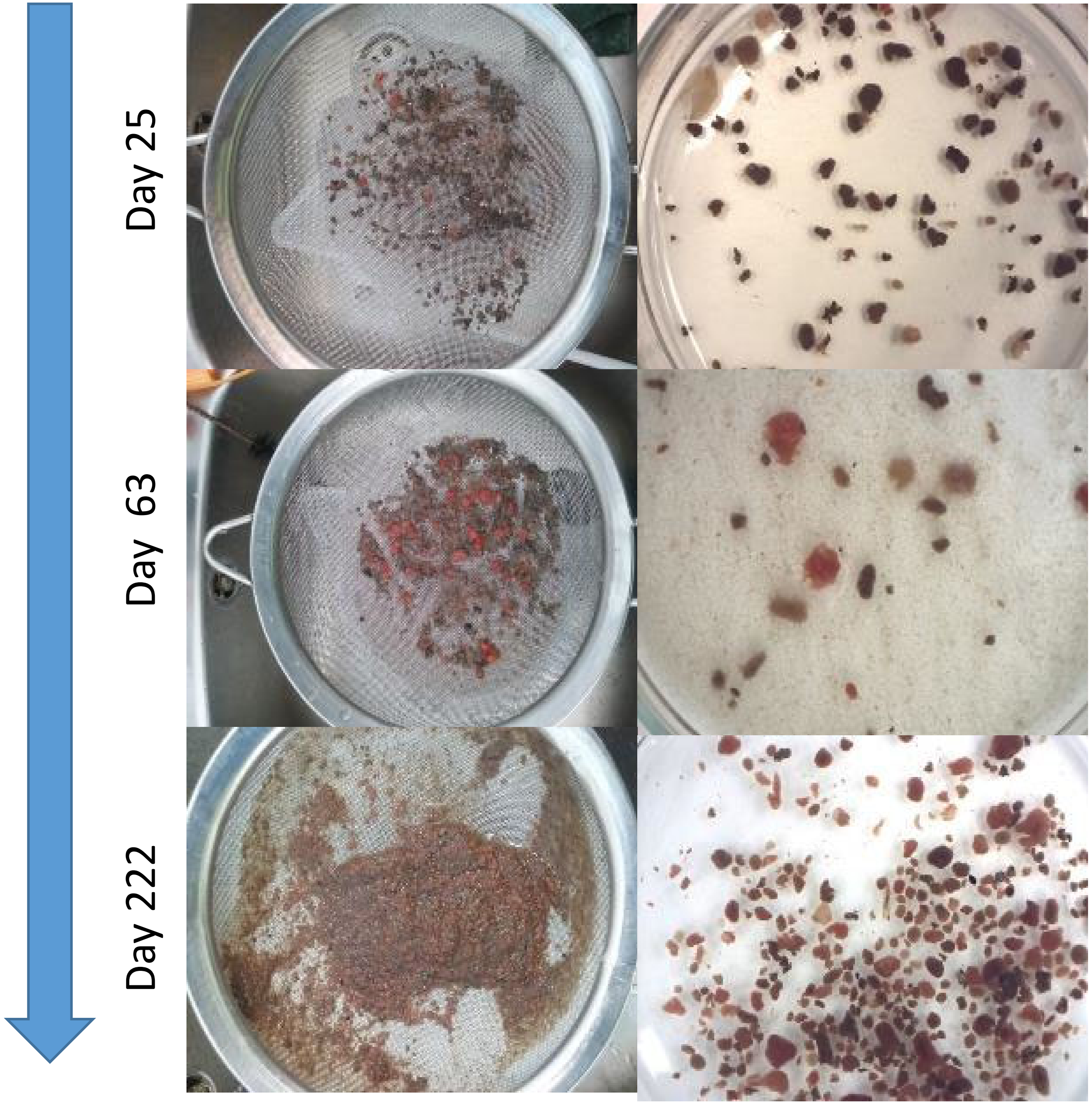
400 – 700 mg NH_4^+-N/L

Consorcio de Augas do Louro

Nitrogen removal rates over 350 mg N/(L·d)



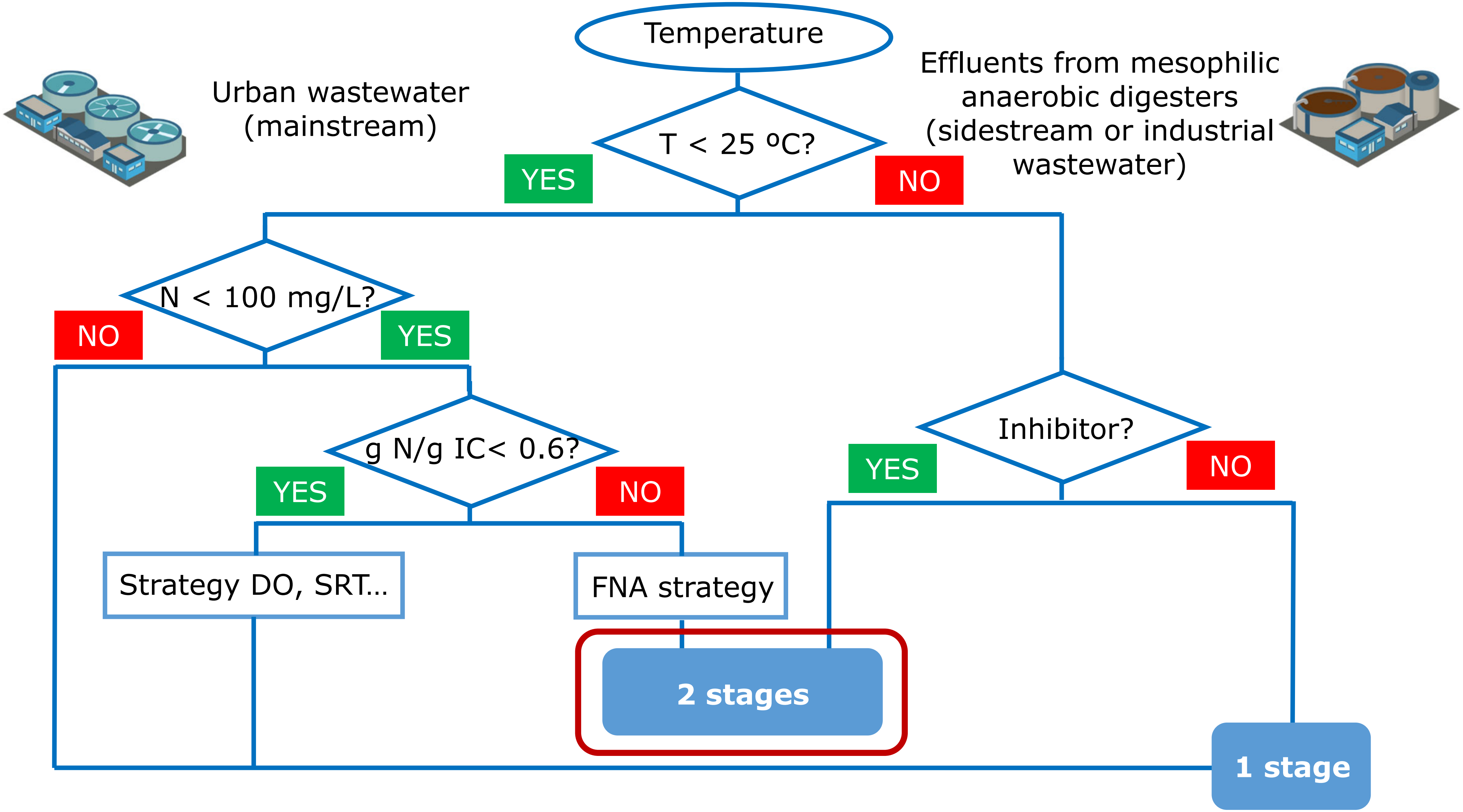
Granular biomass is accumulated in the SBR



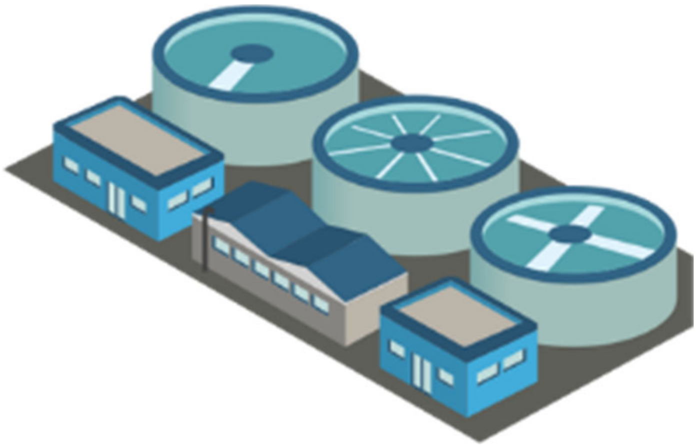
Biomass granulation

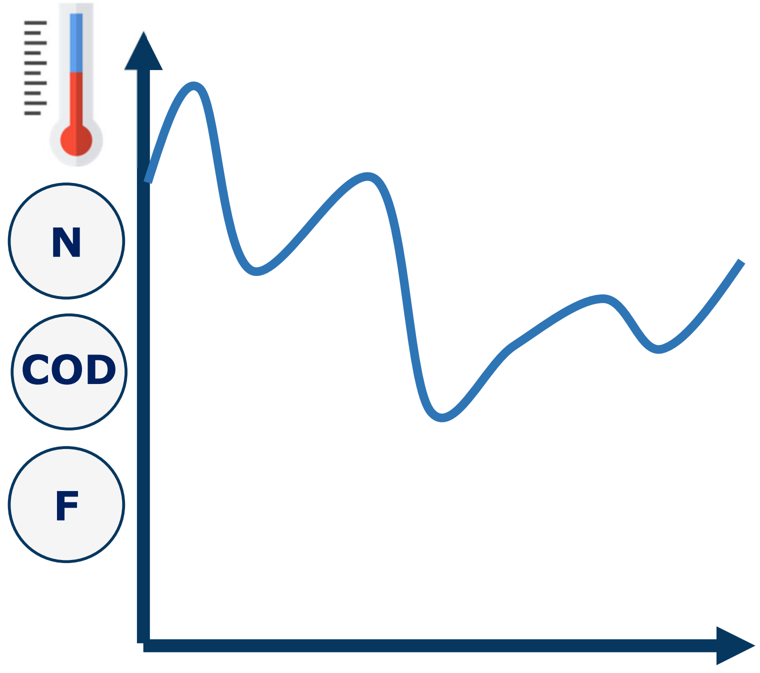
Biomass accumulation

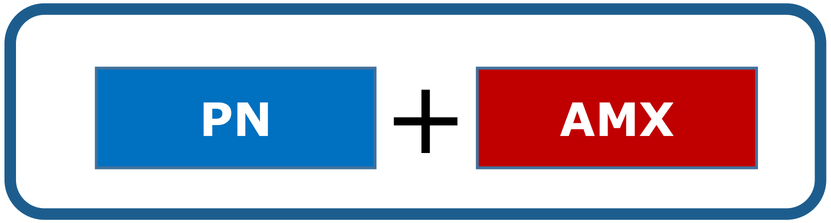
Selection of reactors configuration for PN/AMX

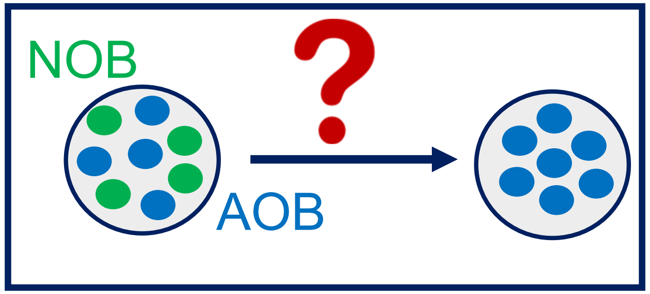


Municipal wastewater shows high variability that might compromise the PN/AMX process stability







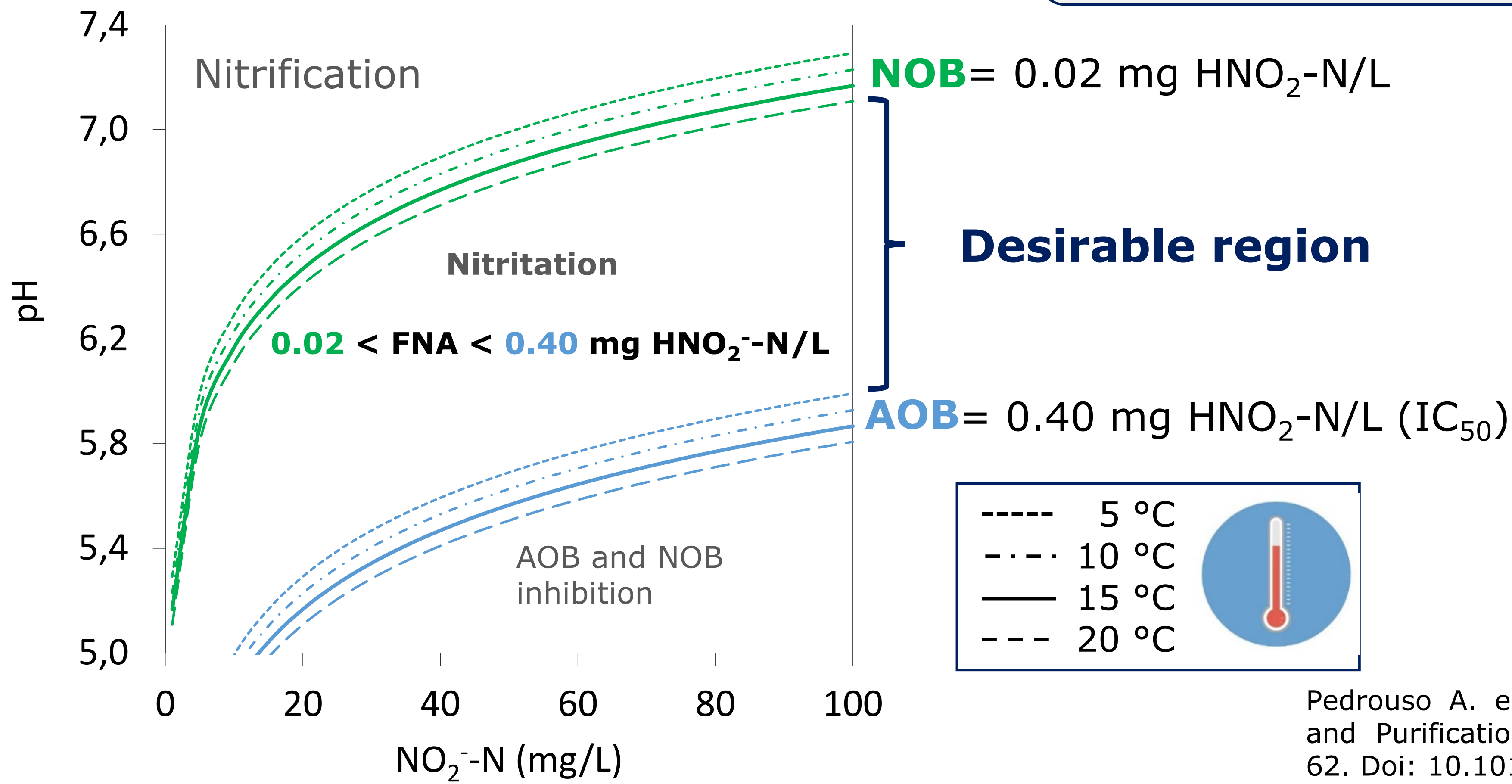


COD: Chemical oxygen demand; N: nitrogen; F: Flow.

Two-unit system: NOB are more sensitive to free nitrous acid (FNA) than AOB in the PN unit

$$HNO_2 \rightleftarrows NO_2^- + H^+,\ pK_a = 3.25$$

$$FNA(HNO_2) = \frac{NO_2^- - N}{10^{pH} e^{-2300/(T+273)}}$$



Pedrouso A. et al. (2017). Separation and Purification Technology, 186, 55-62. Doi: 10.1016/j.seppur.2017.05.043

Nitritation: $NH_4^+ + 2\ HCO_3^- + 1.4\ O_2 \rightarrow \boxed{NO_2^-} + 2\ CO_2 + 3\ H_2O$ ↓ pH

Two-stage system: partial nitritation and anammox processes at pilot scale

WWTP Valdebebas (Madrid)

260,000 p.e.

52,000 m^3/d

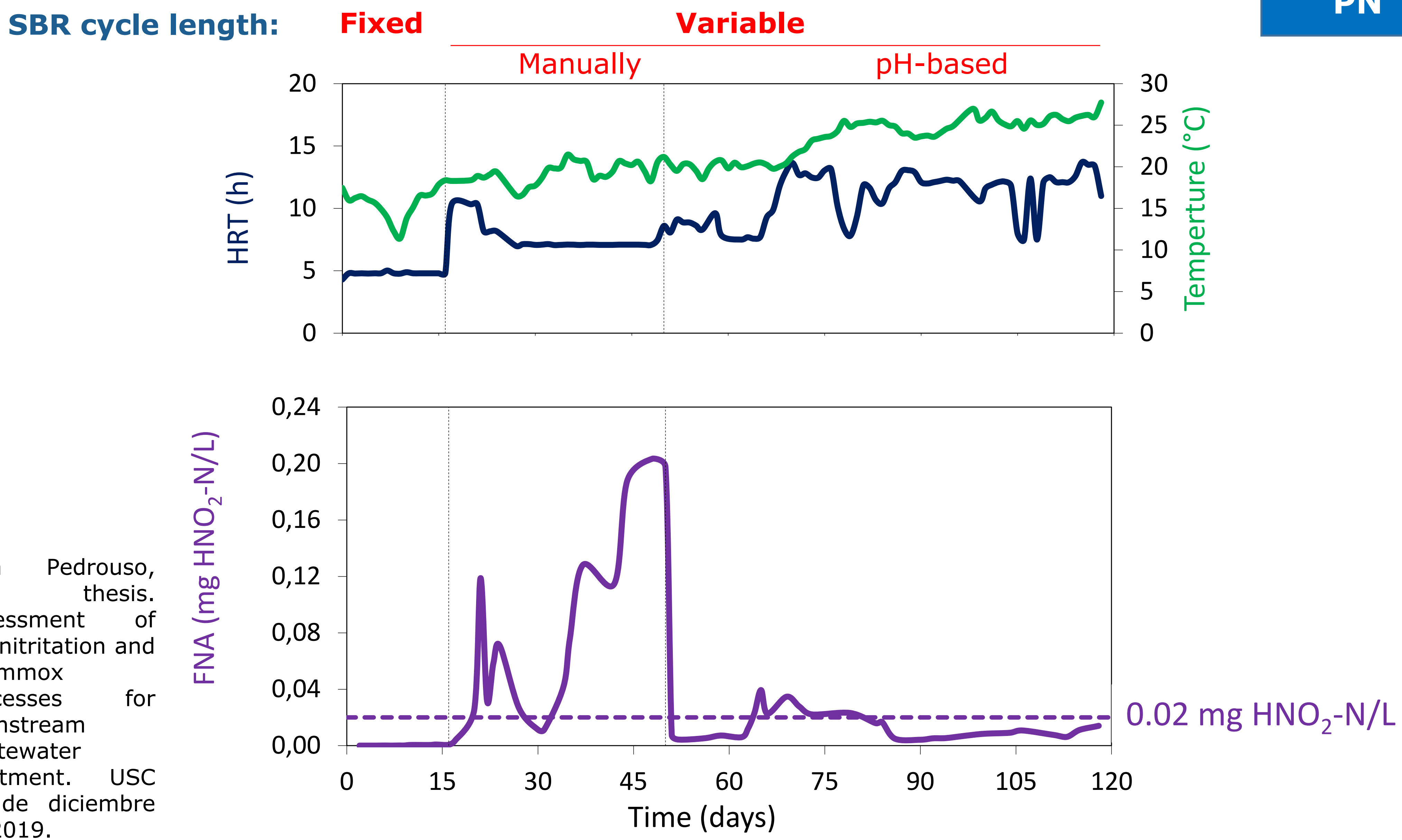
PN **AMX**

Sequencing Batch Reactors (SBR)

Organic matter removed in a **High Rate Activated Sldge (HRAS)** full-scale unit

Nitrite accumulation was promoted due to the FNA accumulation

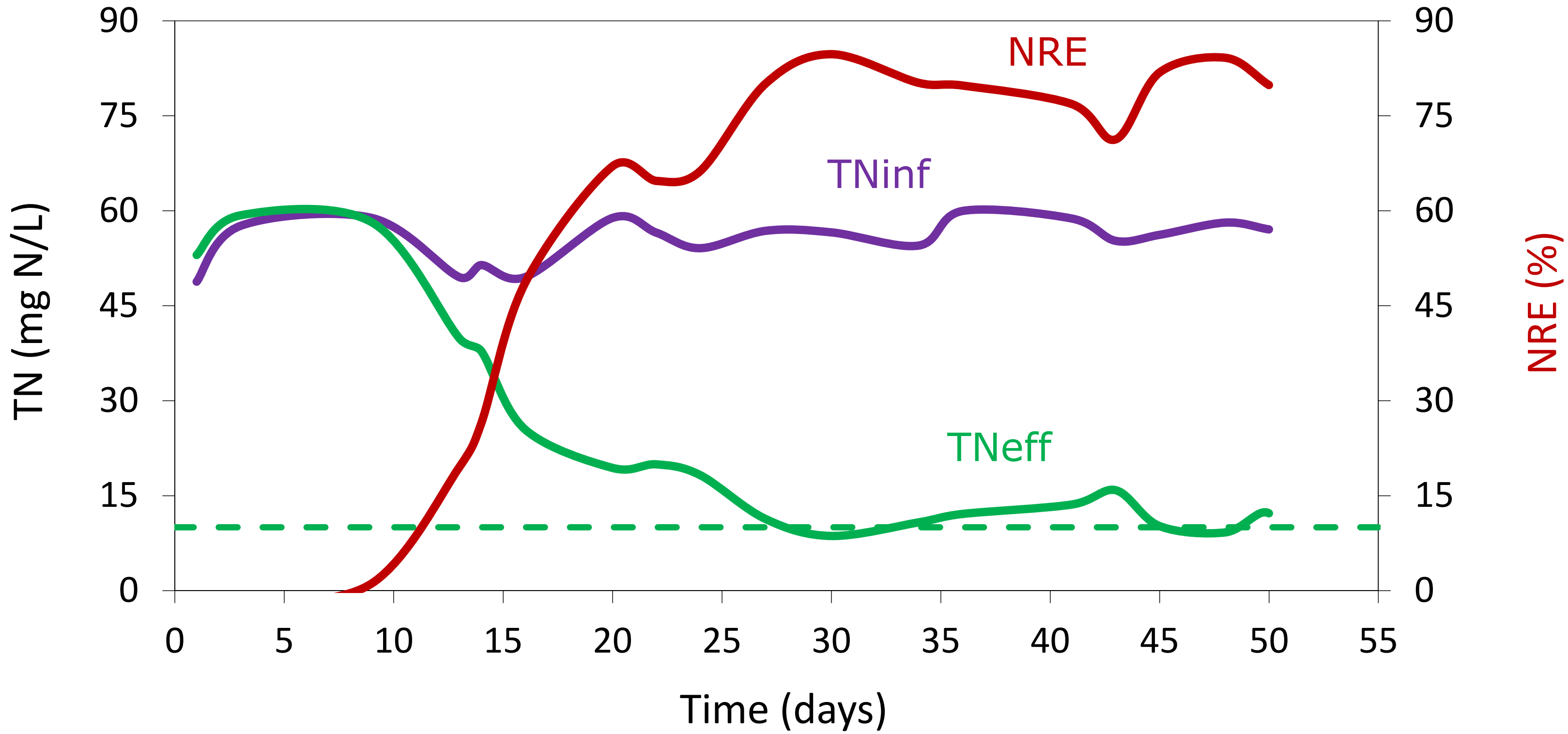
PN



Alba Pedrouso, PhD thesis. Assessment of the nitritation and anammox processes for mainstream wastewater treatment. USC 13 de diciembre de 2019.

Stable anammox process was achieved despite the low influent pH value below 7

AMX



NLR = 115 ± 29 mg N/(L·d)
VSS ≈ 0.5 g VSS/L

NLR: nitrogen loading rate; NRE: nitrogen removal efficiency; TN: total nitrogen

Alba Pedrouso, PhD thesis. Assessment of the nitritation and anammox processes for mainstream wastewater treatment. USC 13 de diciembre de 2019.

Successful implementation of the two-stage PN/AMX at pilot scale

European Patent applied: *EP 16 38 2266*

Partial Nitritation

5 mg NO_3^--N/L

52 mg NH_4^+-N/L

75 mg COD/L

16 ± 15 mg VSS/L

5 mg NO_3^--N/L

26 mg NH_4^+-N/L

26 mg NO_2^- -N/L

70 mg COD/L

Anammox

5+ $\boxed{2}$ mg NO_3^--N/L

4 mg NH_4^+-N/L

1 mg NO_2^- -N/L

56 mg COD/L

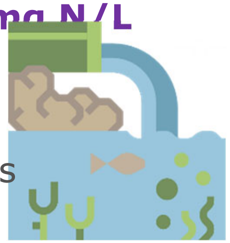
11 ± 4 mg VSS/L

AOB **N~~O~~B**

AMX

Free nitrous acid > 0.02 mg N/L
(if T< 20 °C)

NRE = 80 ± 5 %
NRR = 94 ± 14 mg TN/(L·d)



HRAS optimisation
(60 % nitrate)

Alba Pedrouso, PhD thesis. Assessment of the nitritation and anammox processes for mainstream wastewater treatment. USC 13 de diciembre de 2019.

* Average concentration from the last 25 days
HRAS: High rate activated sludge

Conclusions

- One- and two-stage process are both applicable
- Single stage robustness favoured applicability
- At mainstream two-unit system with NOB inhibition strategies like FNA accumulation (soft water)
- The anammox process is not the most sensitive step

Questions to be solved

- How to cope with effluents from AD with thermal pretreatment or containing inhibitors?
- Is it possible to maintain NOB activity suppresed at mainstream conditions?
- What are the limits of COD concentration for PN/AMX?
- What is the potential of new configurations including partial denitritation-anammox?

Thank you

Anuska Mosquera Corral

Department of Chemical Engineering, Universidade de Santiago de Compostela
Tel. +34 881816779
anuska.mosquera@usc.es

@AnuskaMosquera

info@life-dentreat.eu

The project has received funding from European Union´s LIFE Programme under Grant Agreement LIFE16 ENV/IT/000345