Nitrogen removal via nitrite from reject water produced after dewatering of thermally hydrolyzed and digested sludge

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SMART-Plant

the international water association

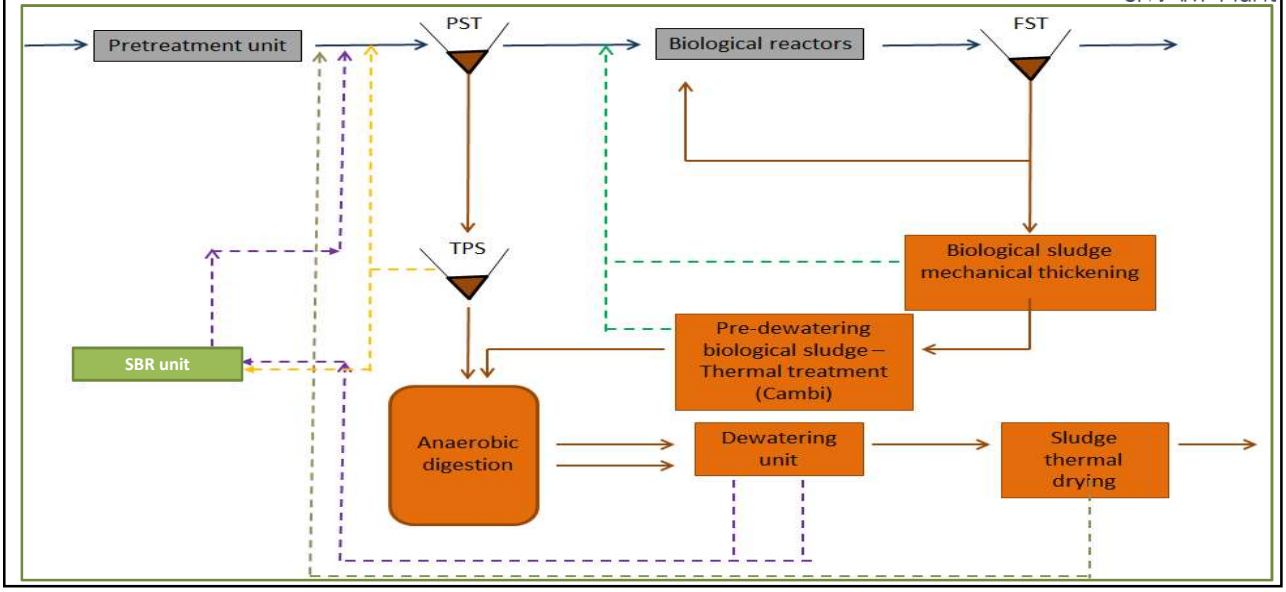
When reject water recycling becomes an issue - Psyttalia WWTP

Equivalent population
- ❑ Design, average: 3 800 000

Sludge Treatment Processes
- ❑ Thickening
- ❑ Thermal hydrolysis of 50% of secondary sludge
- ❑ Digestion
- ❑ Dewatering
- ❑ Thermal drying

- ❑ **Sludge reject water produced from the above processes is recycled and it increases the inlet nitrogen load of the plant by >20%**

Flow diagram of the WWTP and the pilot unit



Nitritation/denitritation

Nitritation: $NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$ (AOB; NOB)

Denitritation: $NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

Pathway

Autotrophic bacteria | Heterotrophic bacteria

Short-cut nitrification/denitrification (SCDN)

Advantages

- Up to 25% lower oxygen demand
- Up to 40% less external carbon source
- 20 – 30% less sludge production

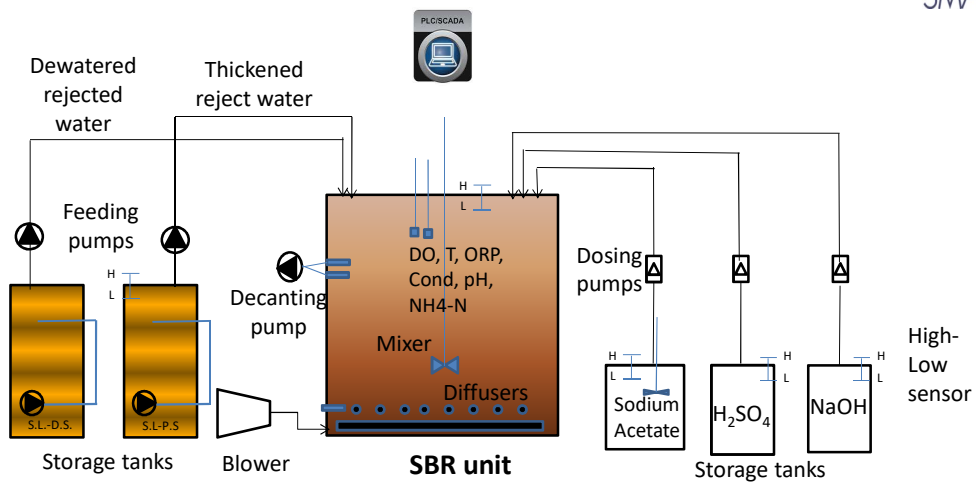
The application of the process in SBR ensures:

- Higher kinetics
- Less working volume
- Higher flexibility

AOB growth, NOB wash-out:

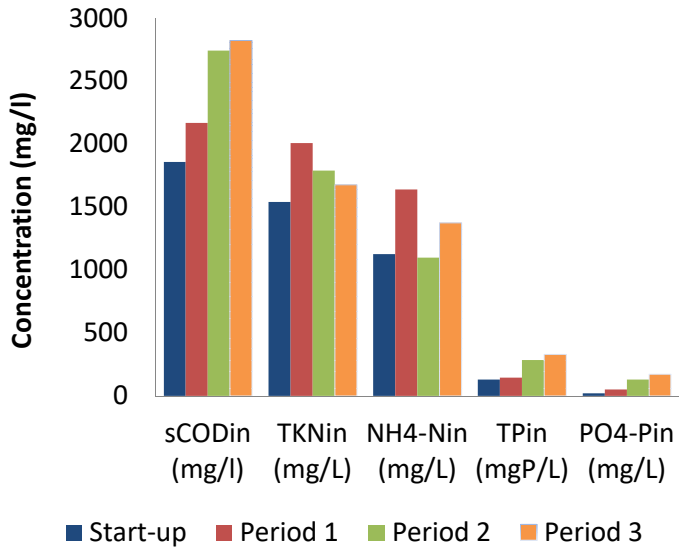
- FA > 1 mg NH_3-N L^{-1}
- FNA > 0.02 mg HNO_2-N L^{-1}
- pH > 7.5
- T: 30-40°C
- DO: 0.5-1.5 mg L^{-1}

Major parts of the pilot plant



Overview of the pilot plant Thermal Hydrolysis -SCENA process

Influent characteristics of sludge reject water

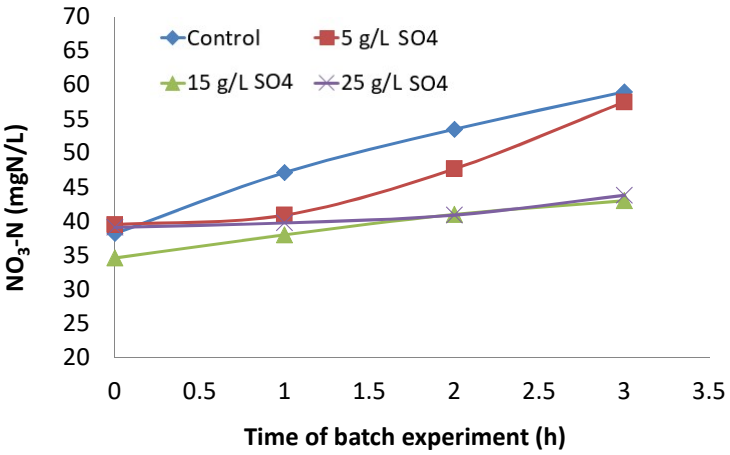


- Reject water of Psyttalia WWTP undergoes thermal hydrolysis prior to the anaerobic digestion process and is characterized of:
- Very high TKN and ammonium nitrogen concentrations (>1.5 >1.1 gN/L respectively).
- Low COD biodegrabillity (6-9% of the total soluble COD).

SBR operating conditions

Parameter	Start-up (Days 1-85)	1st period (Days 85-185)	2nd period (Days 185-258)	3rd period (Days 260-290)
pH	8.4±0.15	8.3±0.3	8.3±0.2	8.4±0.2
Carbon source	Acetic Acid	Acetic Acid & Thickened reject water	Acetic Acid	Acetic acid
HRT	15.4±5.4	6.7 ±2.2	5.2±0.74	3.7±0.27
NLR_TKN (kg N m^{-3} d^{-1})	0.09±0.06	0.32±0.11	0.35±0.10	0.51±0.11
NLR_NH_4-N (kg N m^{-3} d^{-1})	0.07±0.05	0.24±0.08	0.23±0.04	0.40±0.03
DO (mg L^{-1})	>2	>2	>2	>2
MLVSS (mg L^{-1})	1635±866	4807±944	5287±1038	5689±509

Start-up problems



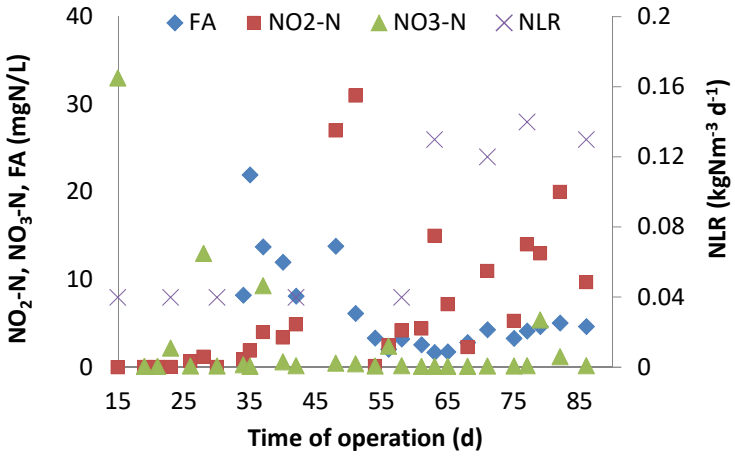
- pH maintained at 7.4±0.4
- Excessive sulfate accumulation
- Conductivity rose from 7 to > 20 ms/cm

AUR Inhibition:

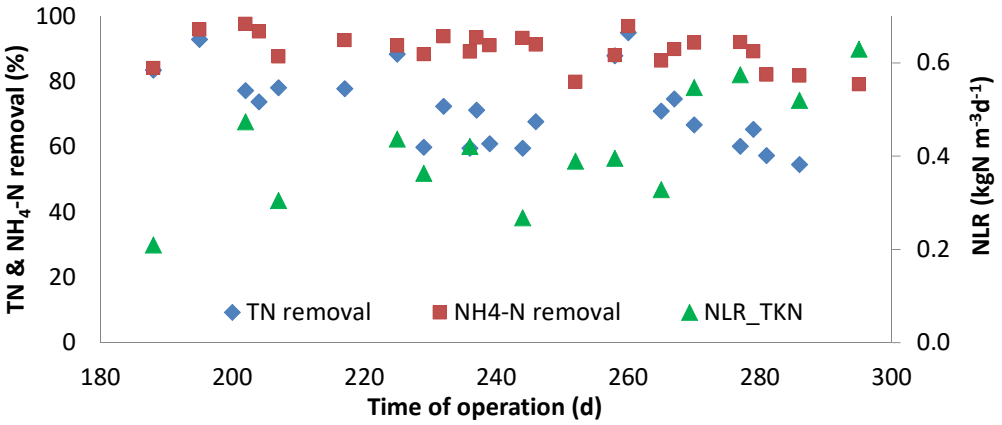
- 16.7% for 5 g/L SO_4^{2-}
- 61.1% for 15 g/L SO_4^{2-}
- 77.4 % for 25 g/L SO_4^{2-}

Start-up to accomplish nitrite accumulation

- Conventional nitrification was implemented during the first 35 days before nitrite accumulation.
- The increase of **NLR** from **0.04 to 0.12-0.14 kgNm^{-3}d^{-1}** resulted in **FA** concentrations **>5 mgN L^{-1}** and led to NOB inhibition.

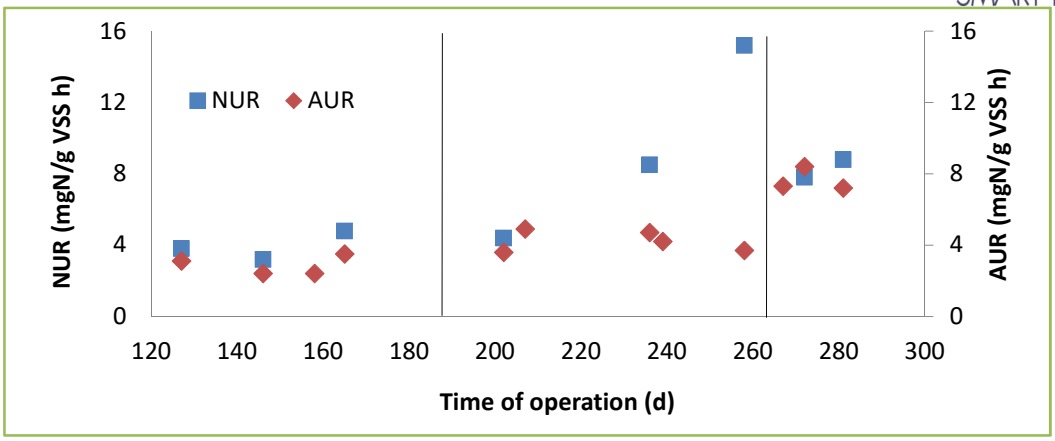


SBR performance during 2nd and 3rd period



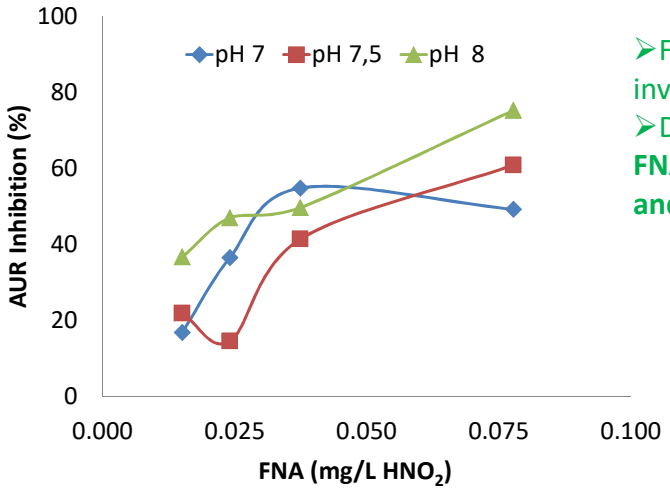
- The **NLR** increased from **0.32±0.10 to 0.51±0.11 kg N m^{-3} d^{-1}** while maintaining high NH4-N removal (always above 88.5%)

AUR and NUR during each period



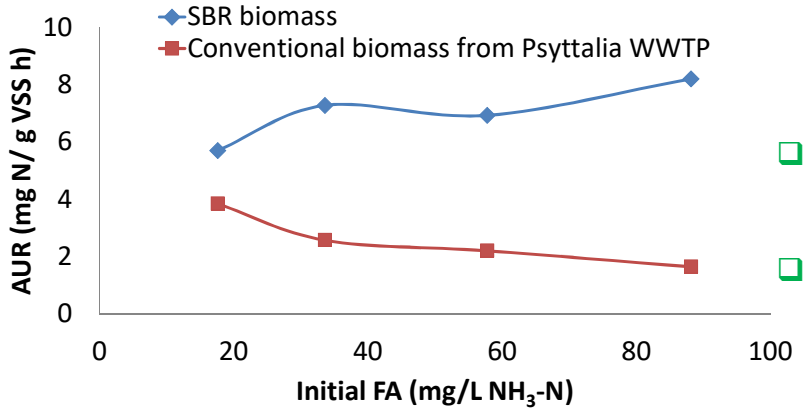
The **AUR** was increased from 2.9±0.5 to 4.2±0.6 and to **7.6±0.7 $mgNO_2$-Ng VSS^{-1} h^{-1}** while the highest average denitritation rates (**NUR**) was equal to **9.4±5.5 $mgNO_2$-Ng VSS^{-1} h^{-1}**

Investigation of Free Nitrous Acid (FNA) inhibition on AUR



- FNA inhibition on AUR was investigated for 3 pH values.
- Decrease of AUR was observed for **FNA** concentrations **0.015 mg/L HNO_2 and above**.

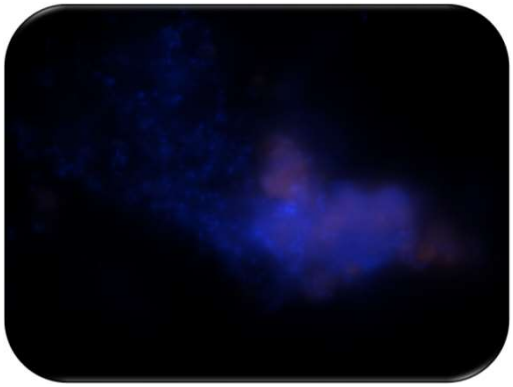
Inhibition of AUR by Free ammonia

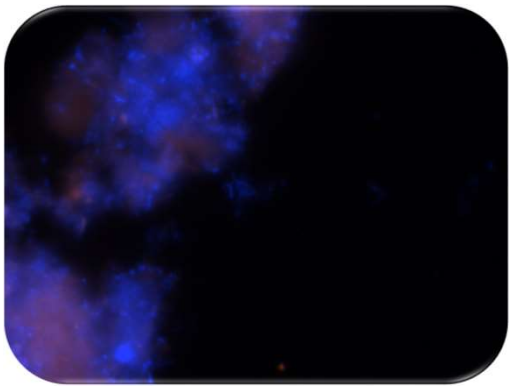


AUR Inhibition:

- No inhibition for SBR biomass
- 33%-57% Inhibition for the biomass of Psyttalia WWTP

AOB and NOB population dynamics calculated by FISH technique





- The bacterial population of **AOB** increased from 23.4% to 35.6% while the **NOB** population decreased from 36.9% to 9.9% as the conventional nitrification replaced by the nitritation/denitritation process.

Conclusions

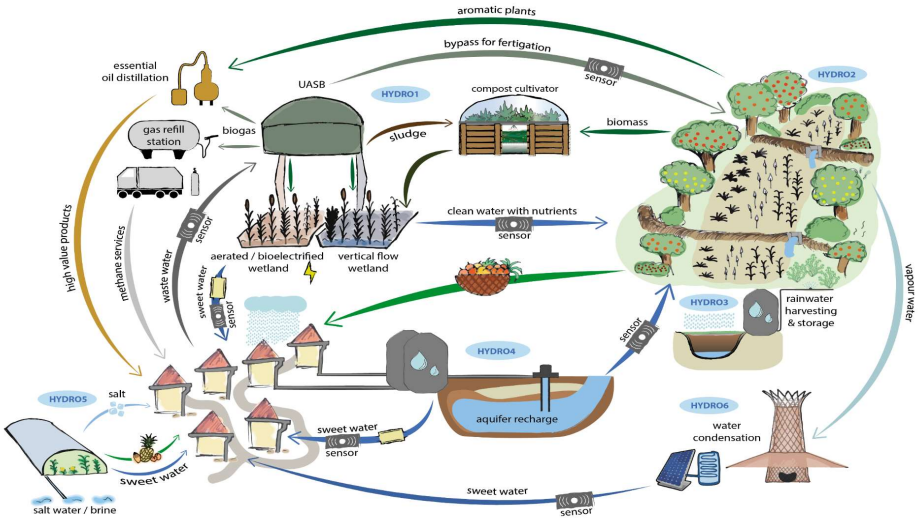
The pilot scale SBR operated under stable conditions achieving:

- Average NLR up to 0.5 kgNH_4-N m^{-3} d^{-1} with HRT les than 4 days
- NH4-N removal: >85%
- TN removal: >65%
- Ammonia uptake rates (AUR) up to 9 mgN $gVSS^{-1}$ h^{-1}
- Nitrite uptake rates (NUR) up to 15 mgN $gVSS^{-1}$ h^{-1}

SMART Plant Project

SMART-Plant has received funding from the European Union's **Horizon 2020** Research and Innovation Programme

HYDROUSA H2020 PROJECT



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