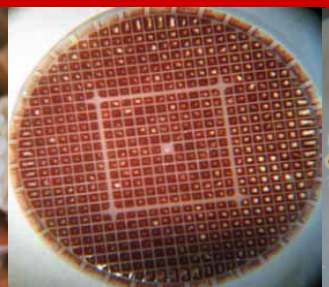
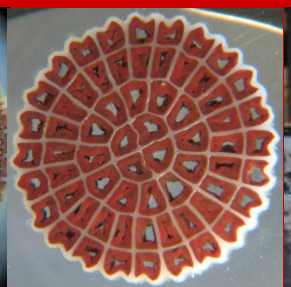
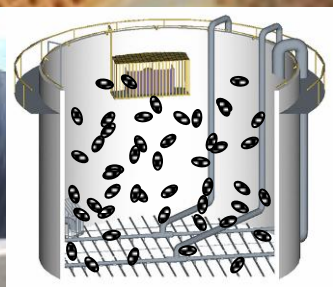
Experience from start-up and operation of ANITA™ Mox plants and development of a new Hybas™ ANITA™ Mox process

Nitrogen Removal Technologies

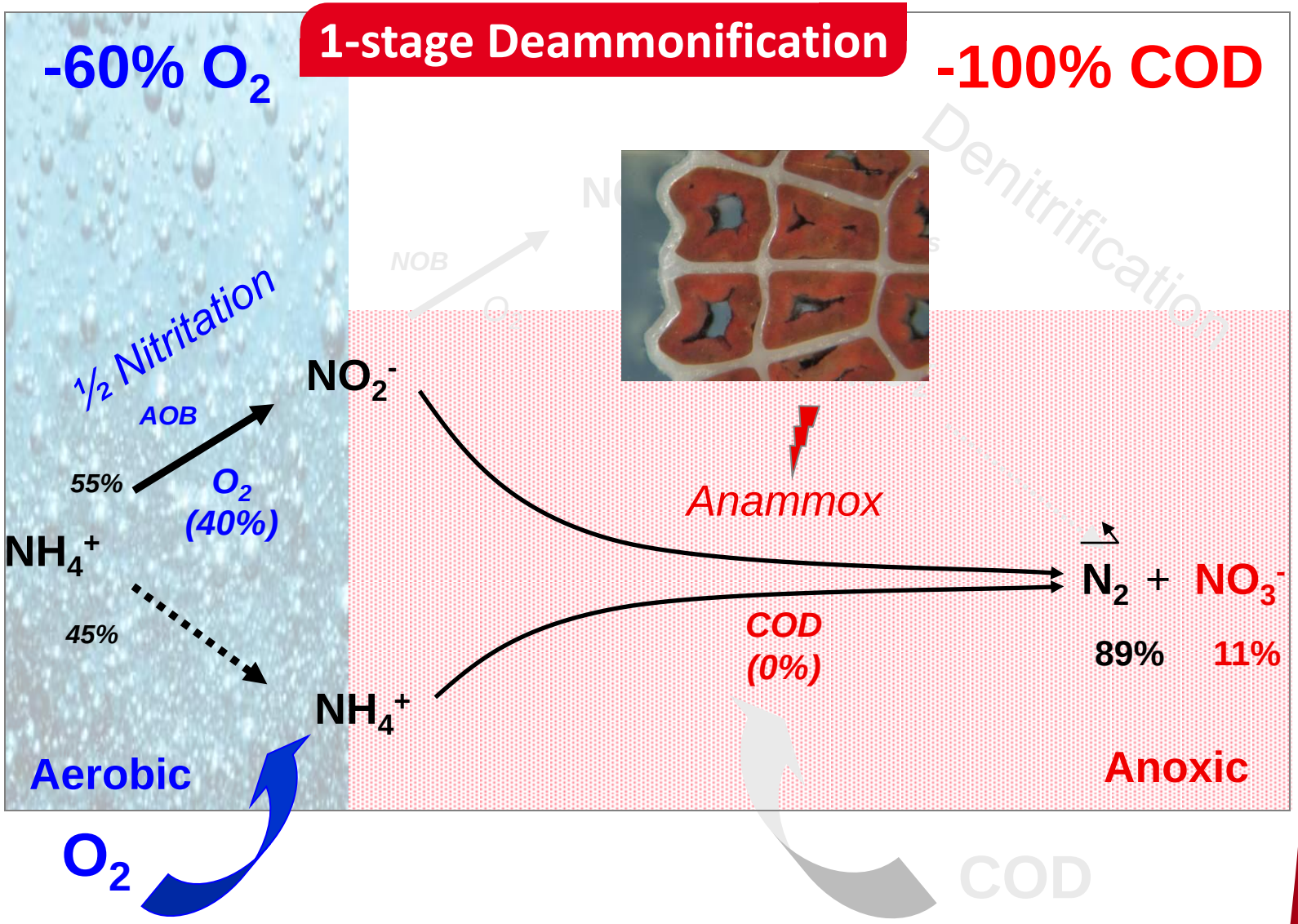
15th May Leeds

Romain Lemaire *(Veolia Water, Paris)*
Magnus Christensson *(AnoxKaldnes)*
Bruno Bigot *(Veolia Water Solutions & Technologies UK)*

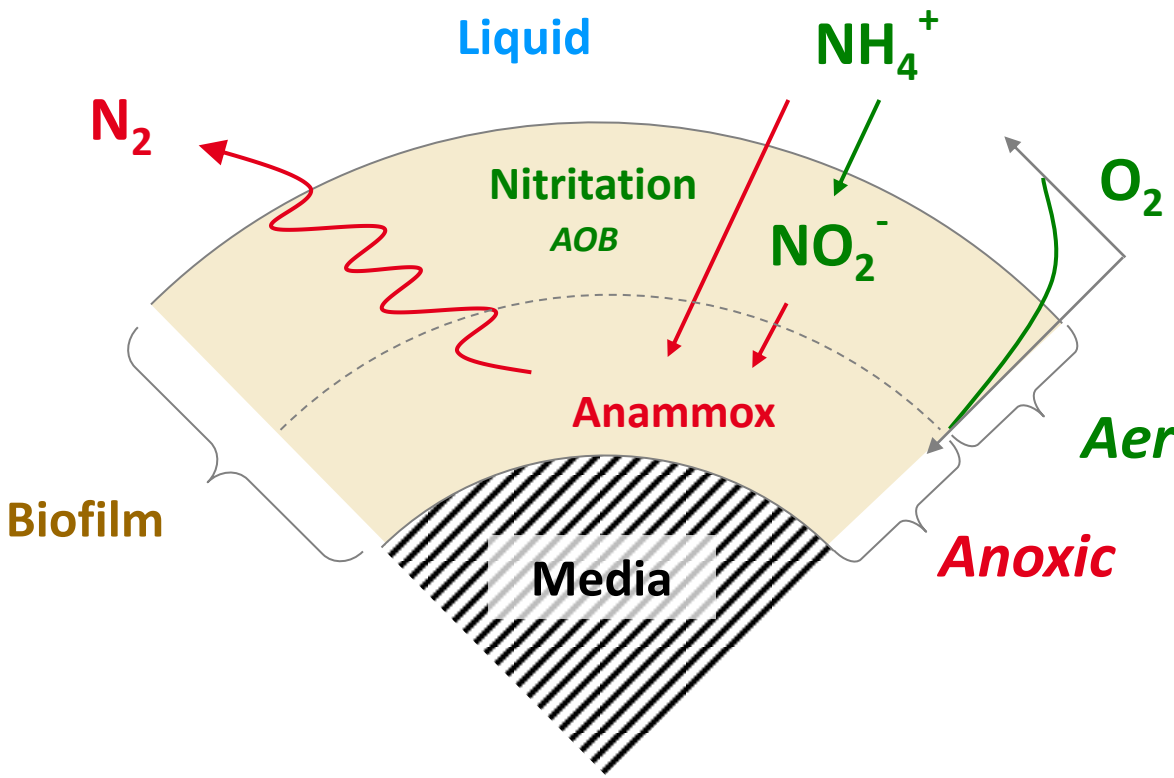
Principle – ANITA™ Mox

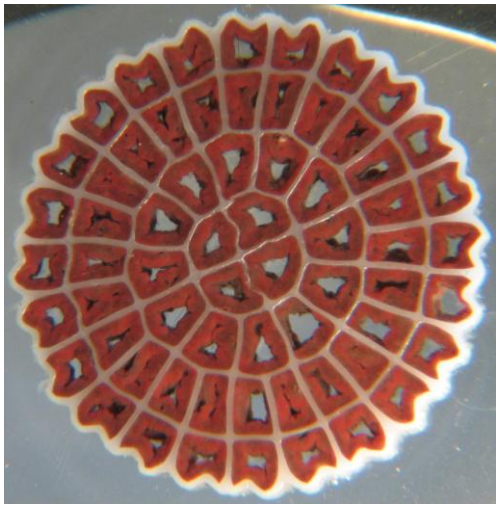


ANITA™ Mox – MBBR process

- High sludge retention time (SRT) needed
- Necessity to protect anammox bacteria (O_2 / NO_2) → Biofilm
- Necessity to keep bacteria into the system (avoid washout)
- Maximum robustness and stability desired

→ **MBBR**

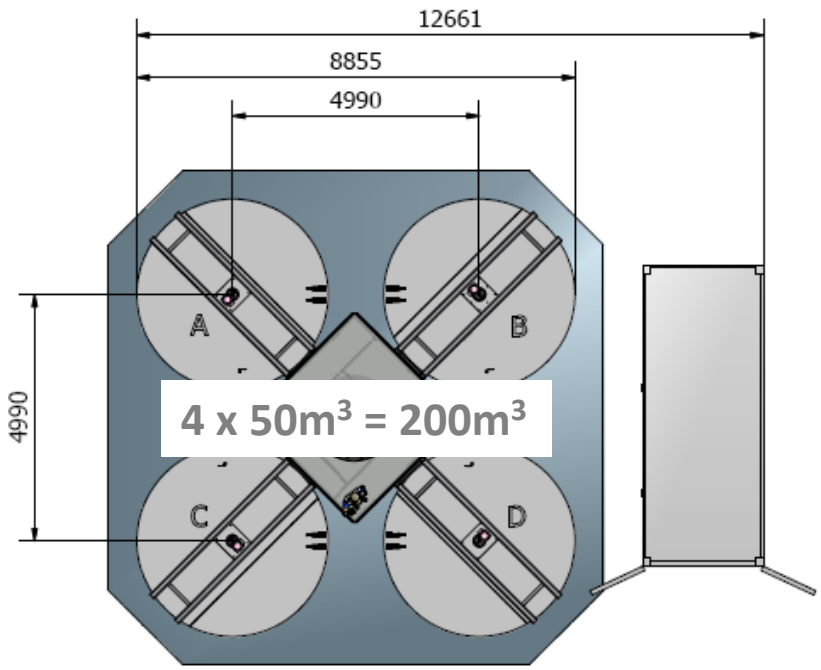


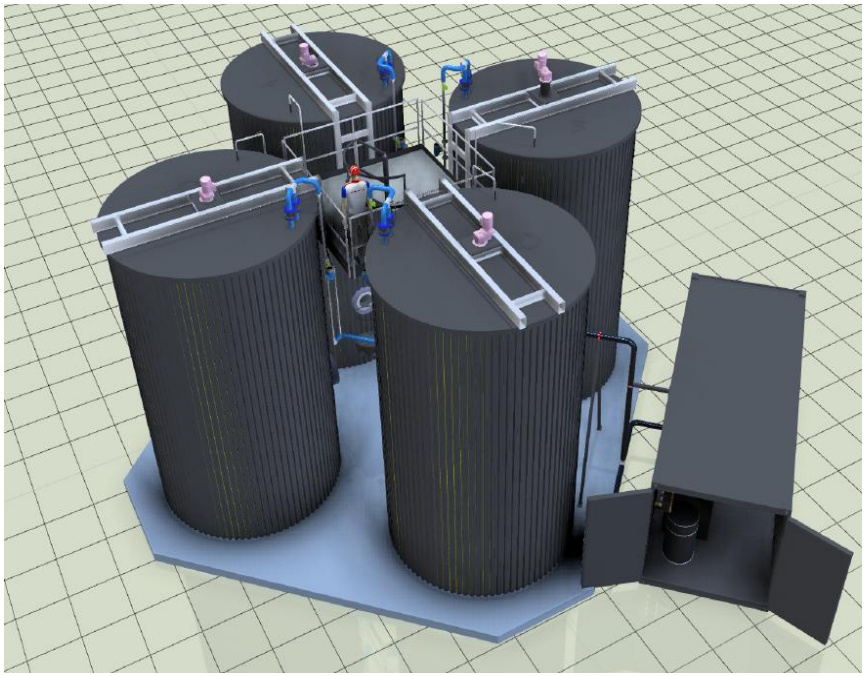


Aerobic

Simultaneous in biofilm

ANITA™ Mox – Sjölunda WWTP, Malmö (Sweden)

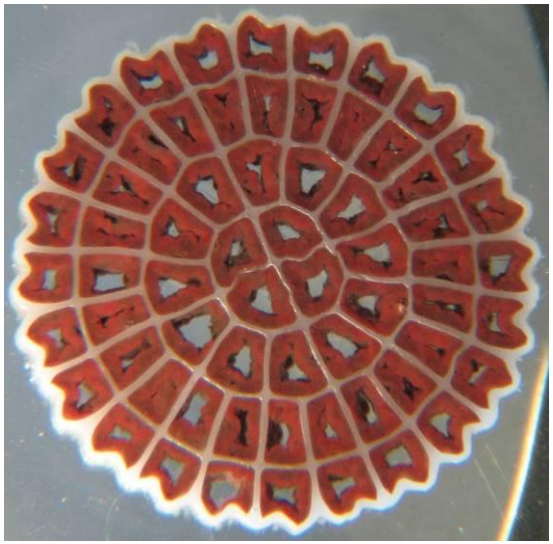




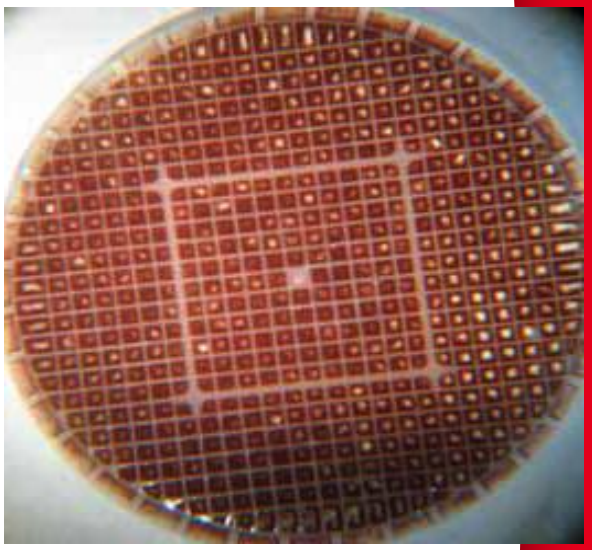
➔ Sjölunda WWTP reject water
➔ Capacity = 200 kgN/d
➔ 800-1200 mgN-NH_4/L
➔ 1st ANITA™ Mox reference
➔ Flexibility for fullscale testing

ANITA™ Mox – Different Media tested

K3
500 m^2/m^3



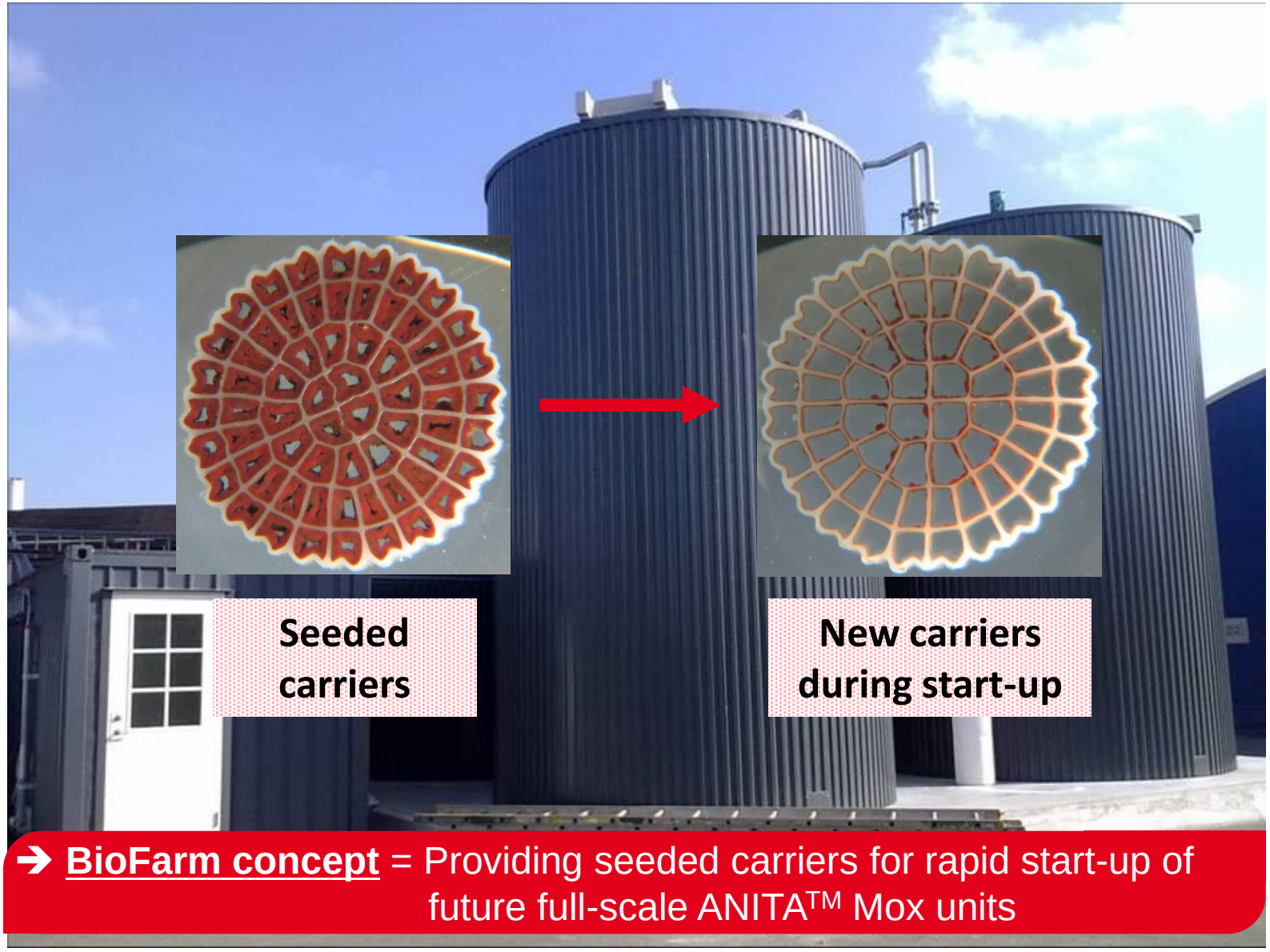
K5
800 m^2/m^3



BiofilmChip M
1200 m^2/m^3

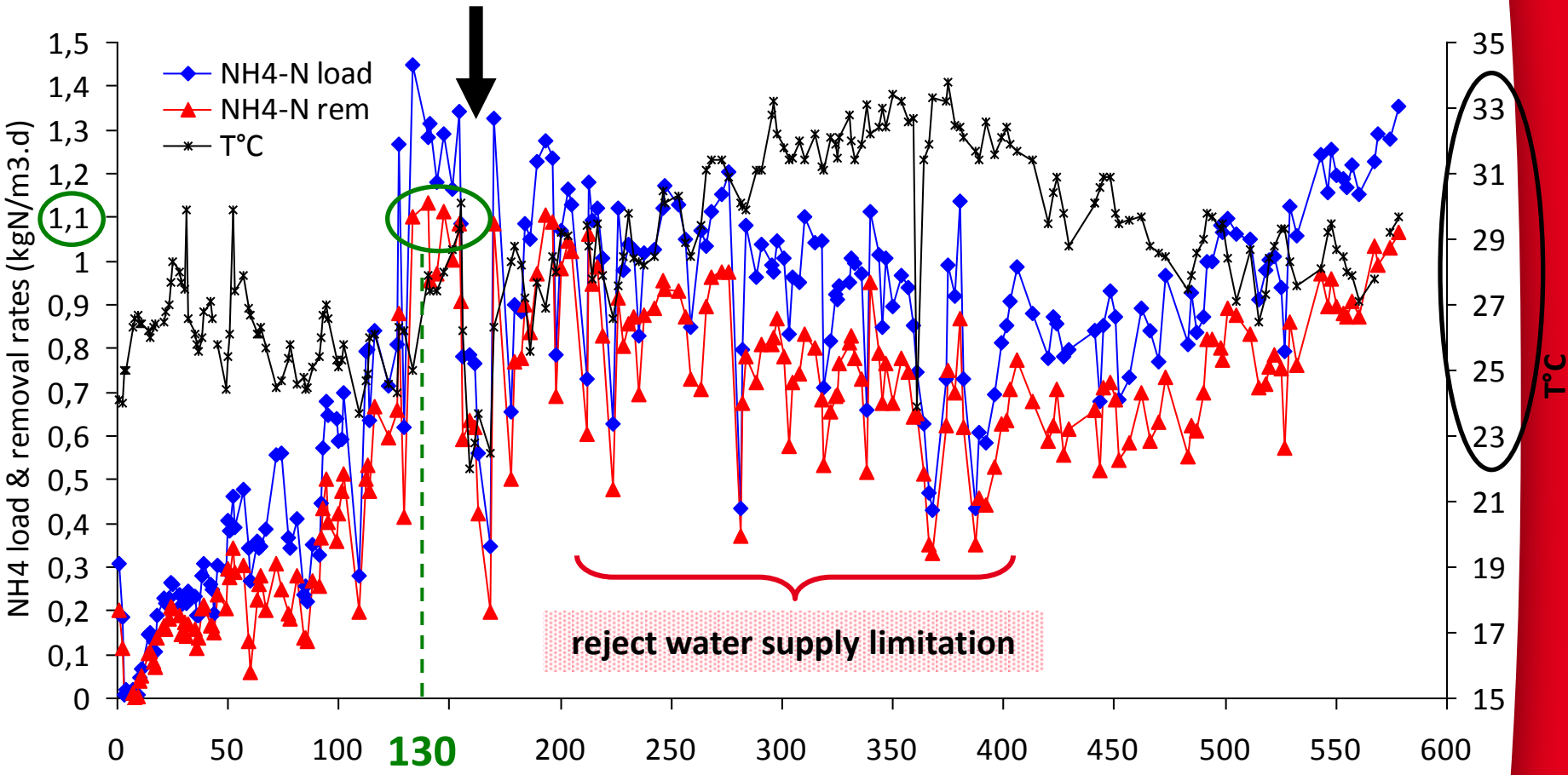
MBBR = Media + Grid ➔ <u>No risk</u> of losing Anammox biomass

ANITA™ Mox – BioFarm concept



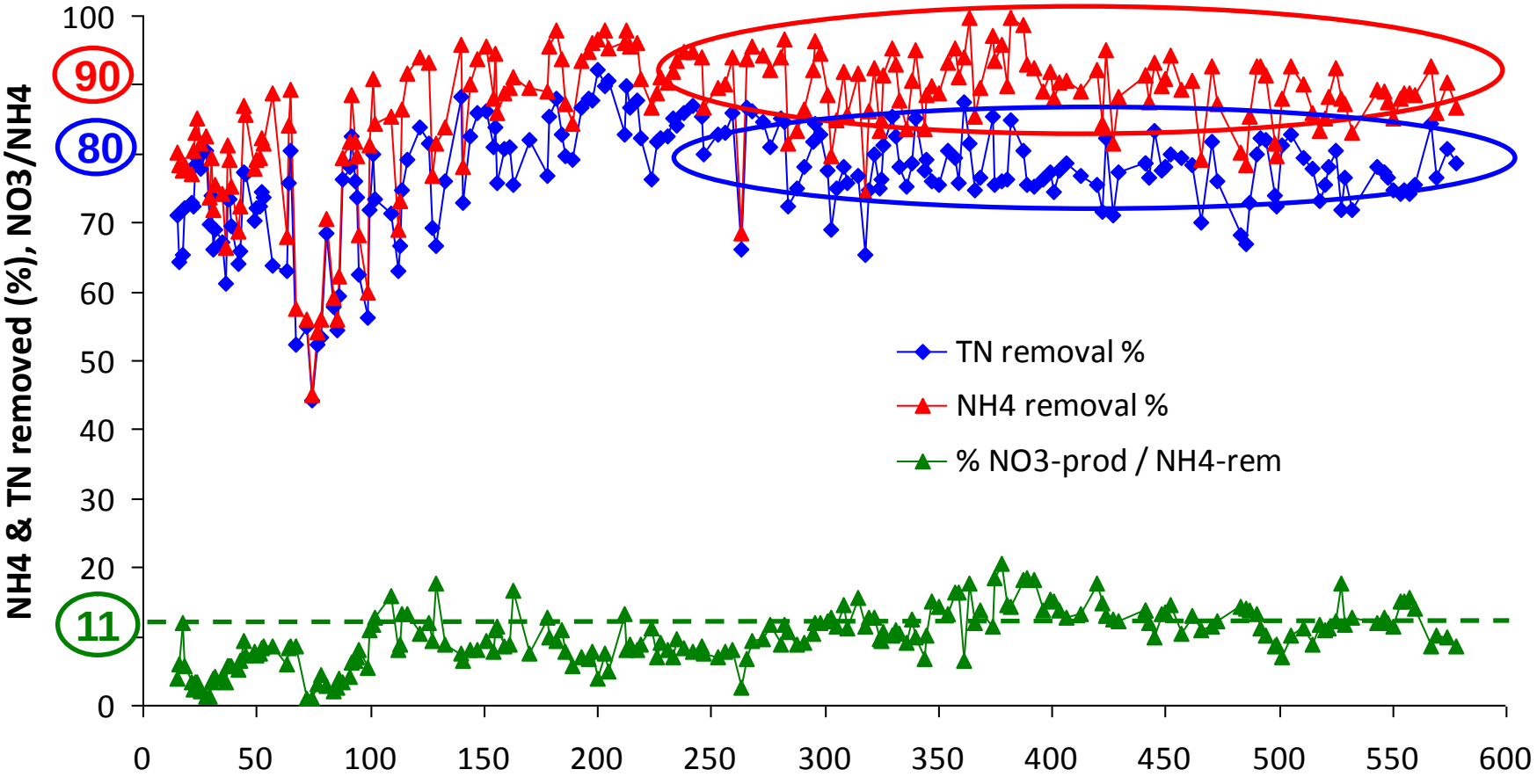
➔ **BioFarm concept** = Providing seeded carriers for rapid start-up of future full-scale ANITA™ Mox units

BioFarm – N-load / NH_4-rem



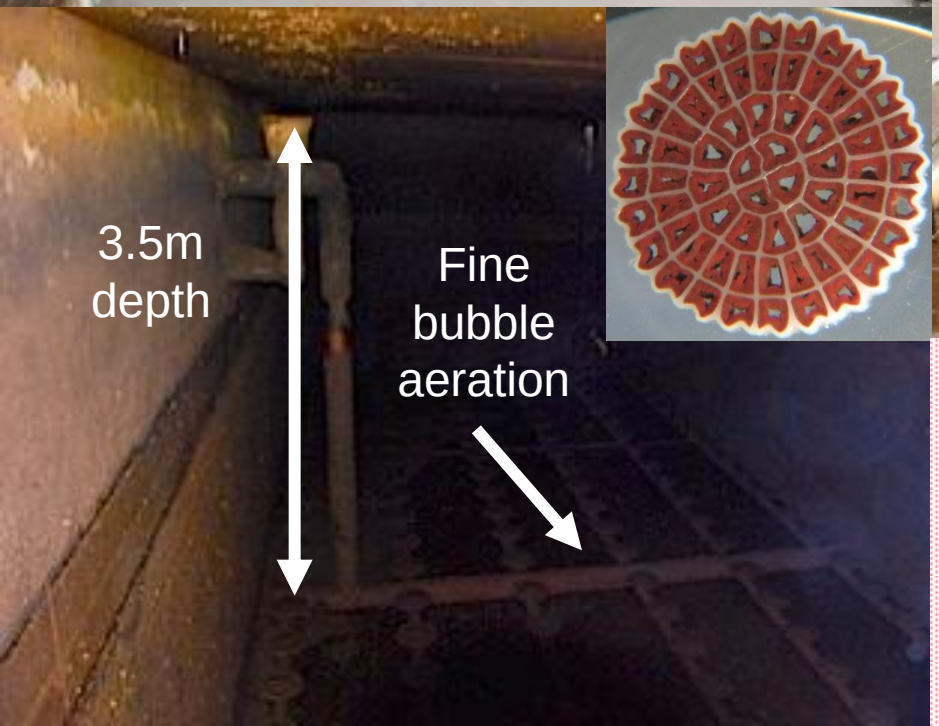
➔ **1.1 kgN-NH_4/m^3.d** in 4 months with only **3% seeding**

BioFarm – Performance



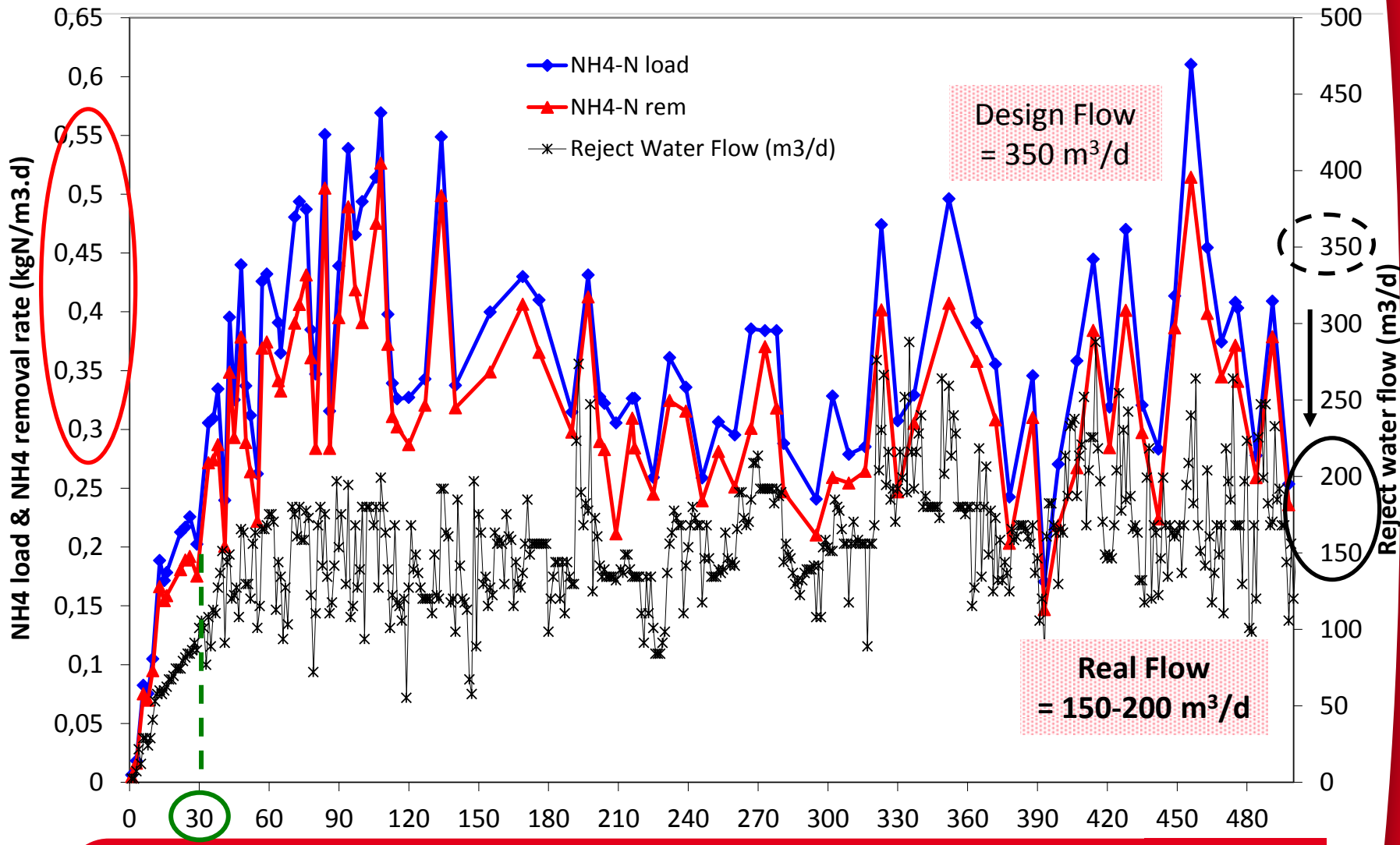
- ➔ **90% NH_4 removal** and **80% TN removal**
- ➔ **Patented DO control** strategy reduce **NO_3 production <11%**
- ➔ **1.4 – 1.7 kWh/kgN-NH_4 removed**

ANITA™ Mox – Sundets WWTP, Växjö (Sweden)



- **350 kgN/d → 430 kgN/d** reject water
- Existing 350m^3 SBR → **MBBR**
- **K5 carrier** (AnoxKaldnes)
- Quick seeding **(13% from BioFarm)**
- **Started** in January 2012

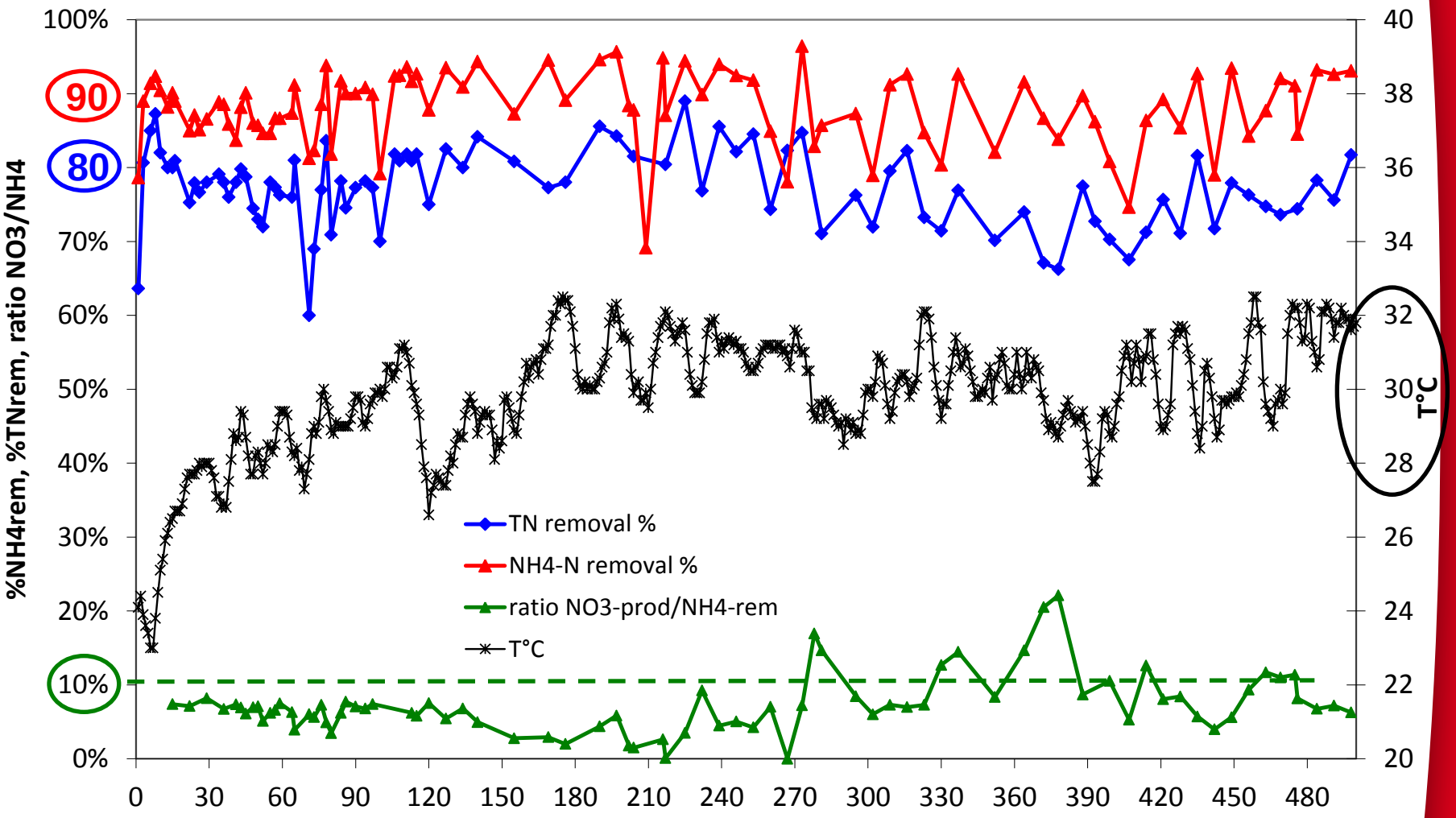
Växjö – N-load / NH_4-rem



➔ Treating **all reject water** after only **30 days** (with **13% seeding**)

➔ **0.4-0.5 kgN/m³.d** → ½ design N-load expected → **Co-digestion 2013**

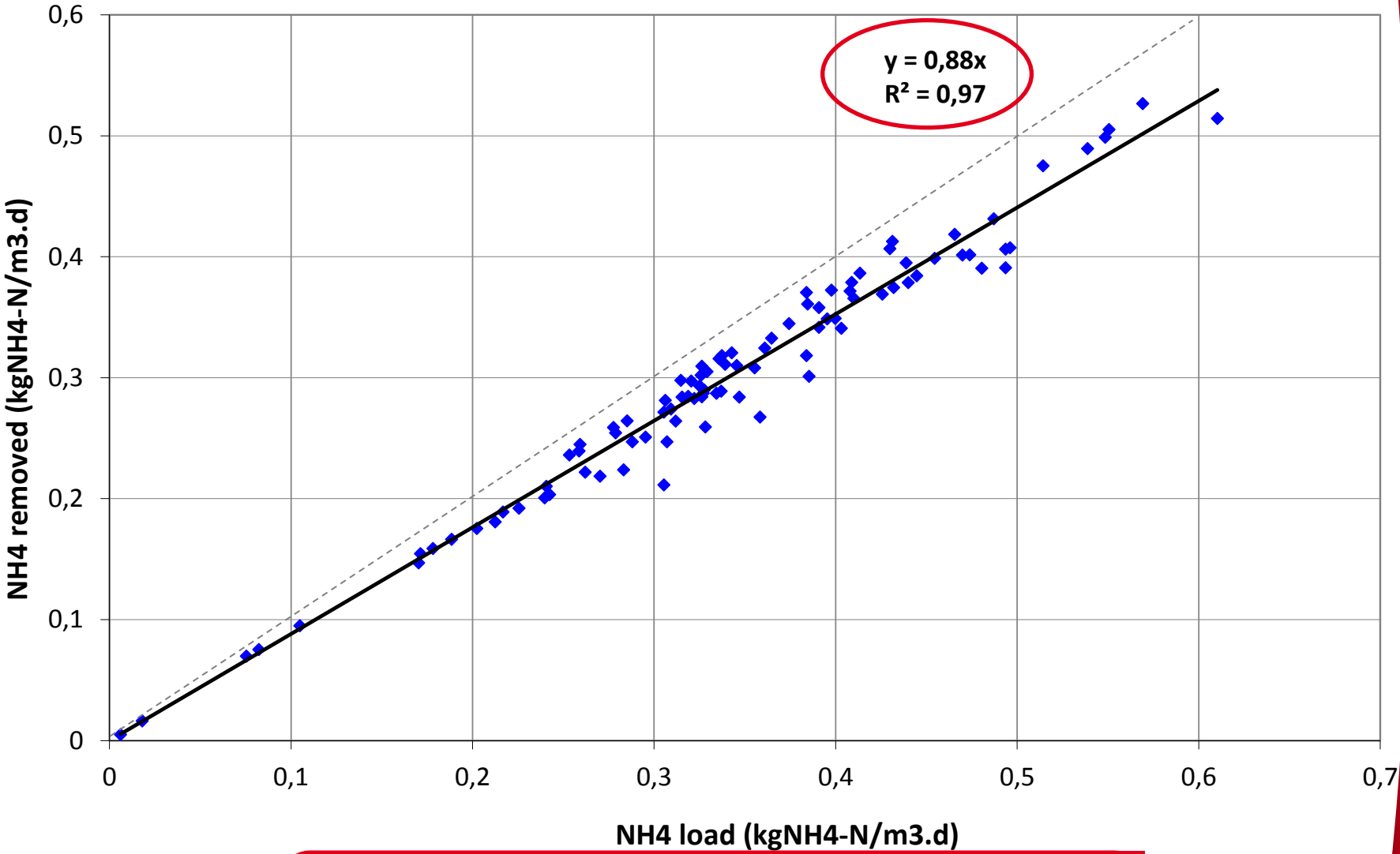
Växjö – Performance



➔ **90% NH_4 removal** and **80% TN removal**

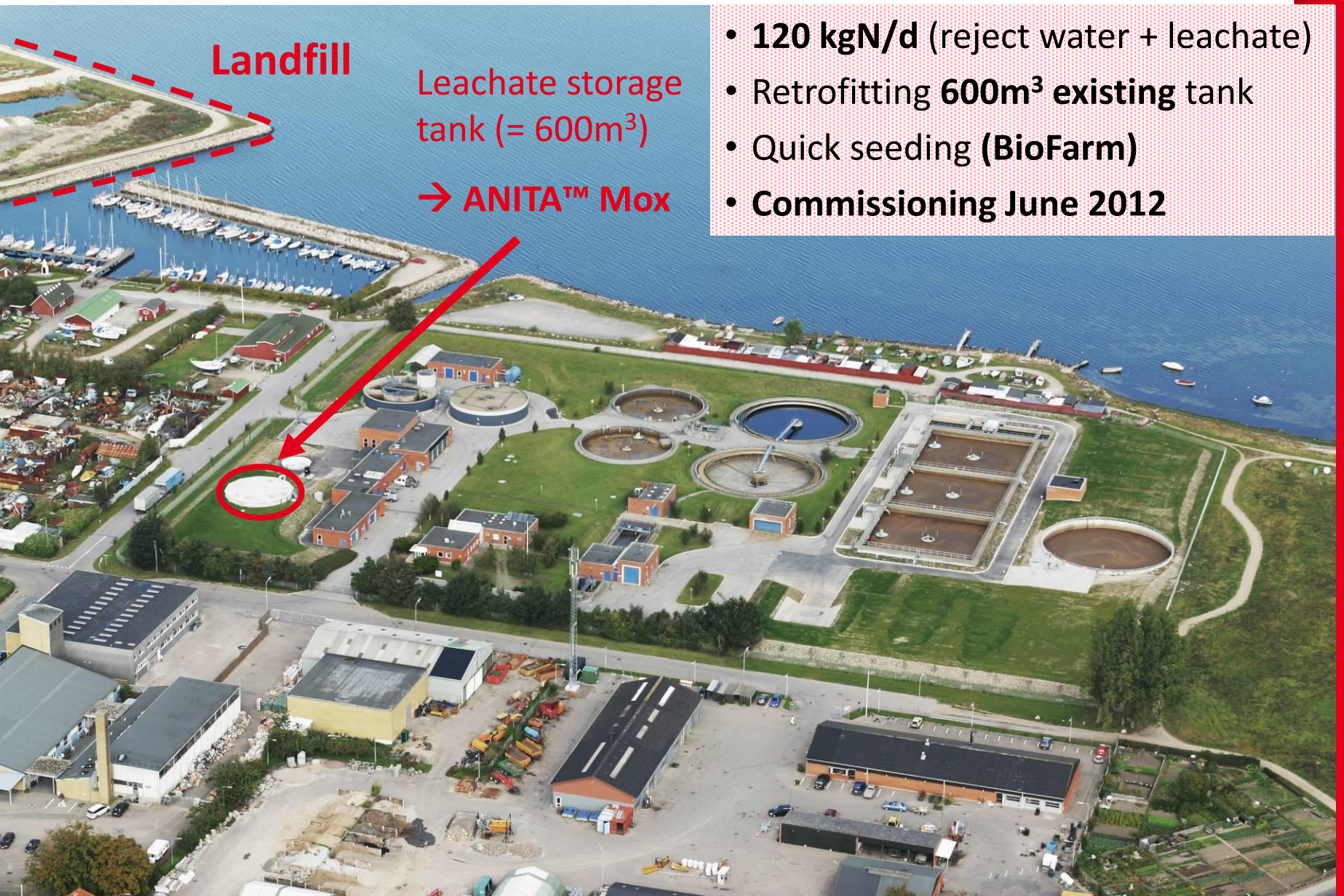
➔ **DO control strategy** reduce **NO_3 production <11%**

Växjö – N-load vs NH_4-removal



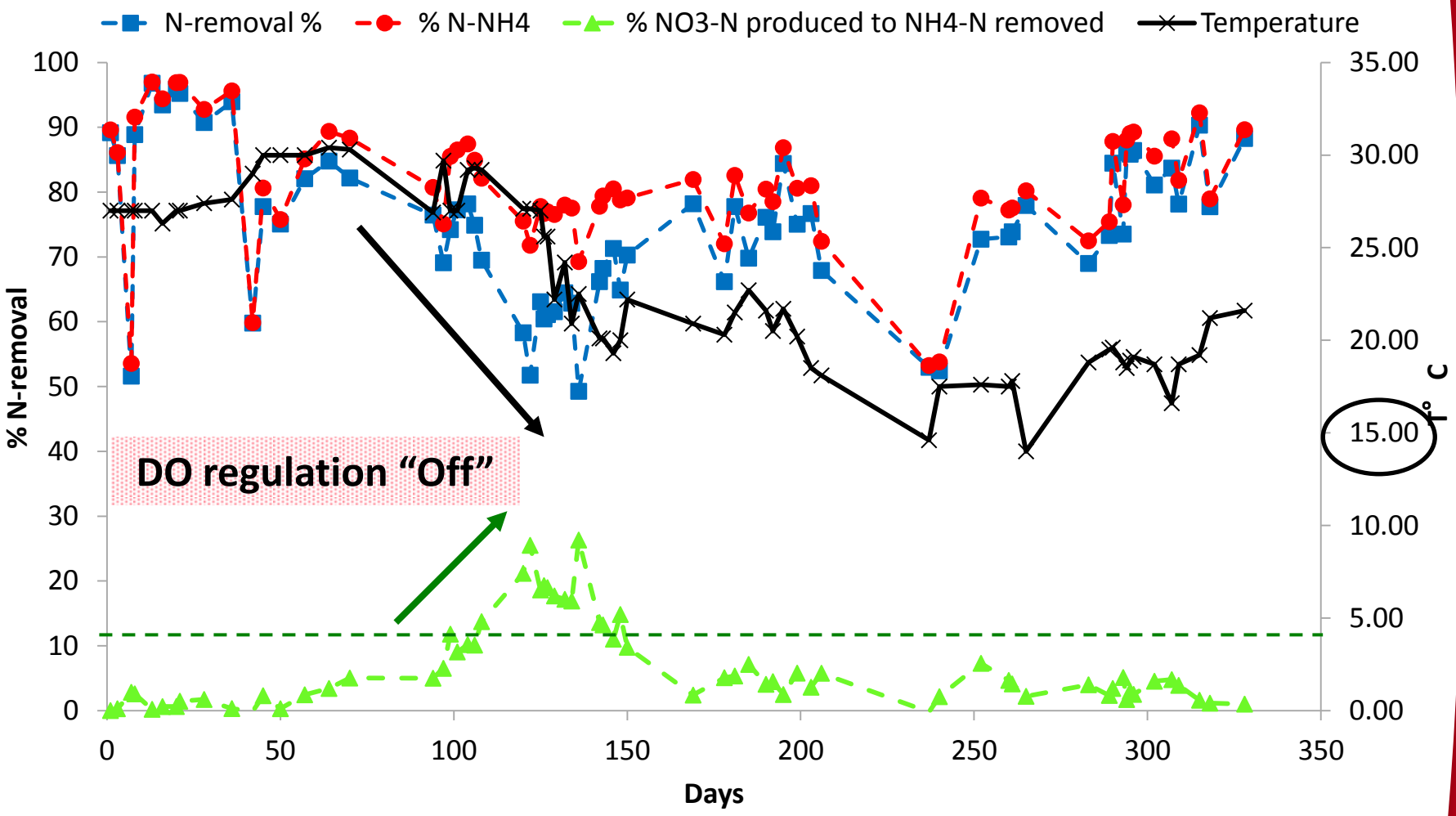
➔ **88% NH_4 removal** since start-up

ANITA™ Mox – Holbæk (DK)



- **120 kgN/d** (reject water + leachate)
- Retrofitting **600m³ existing** tank
- Quick seeding **(BioFarm)**
- **Commissioning June 2012**

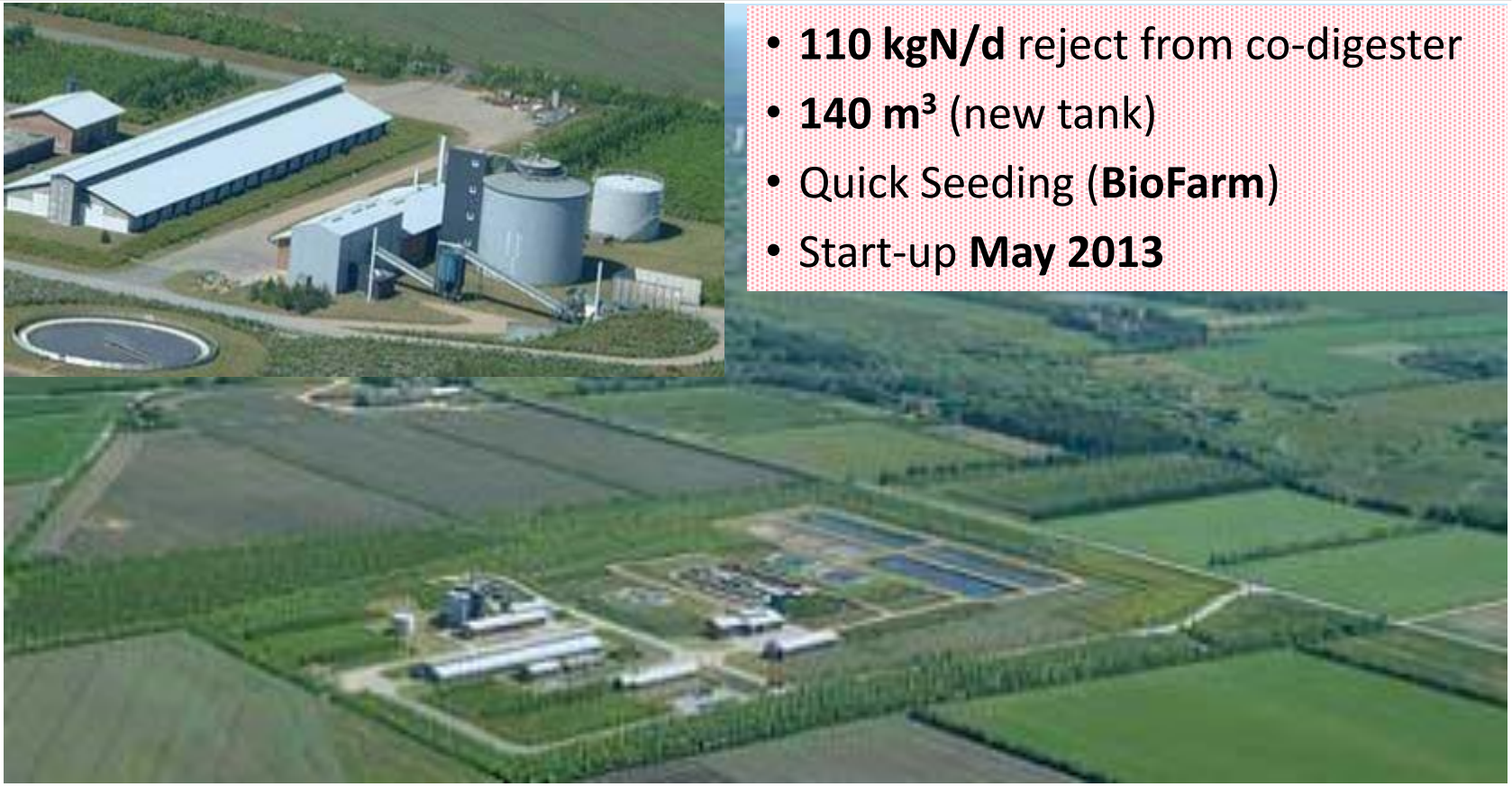
Holbæk – Performance



➔ **80% NH_4 removal** even at **15˚ C**

➔ Patented **DO control strategy** very efficient to keep **NO_3 <11%**

ANITA™ Mox – Grindsted, Denmark



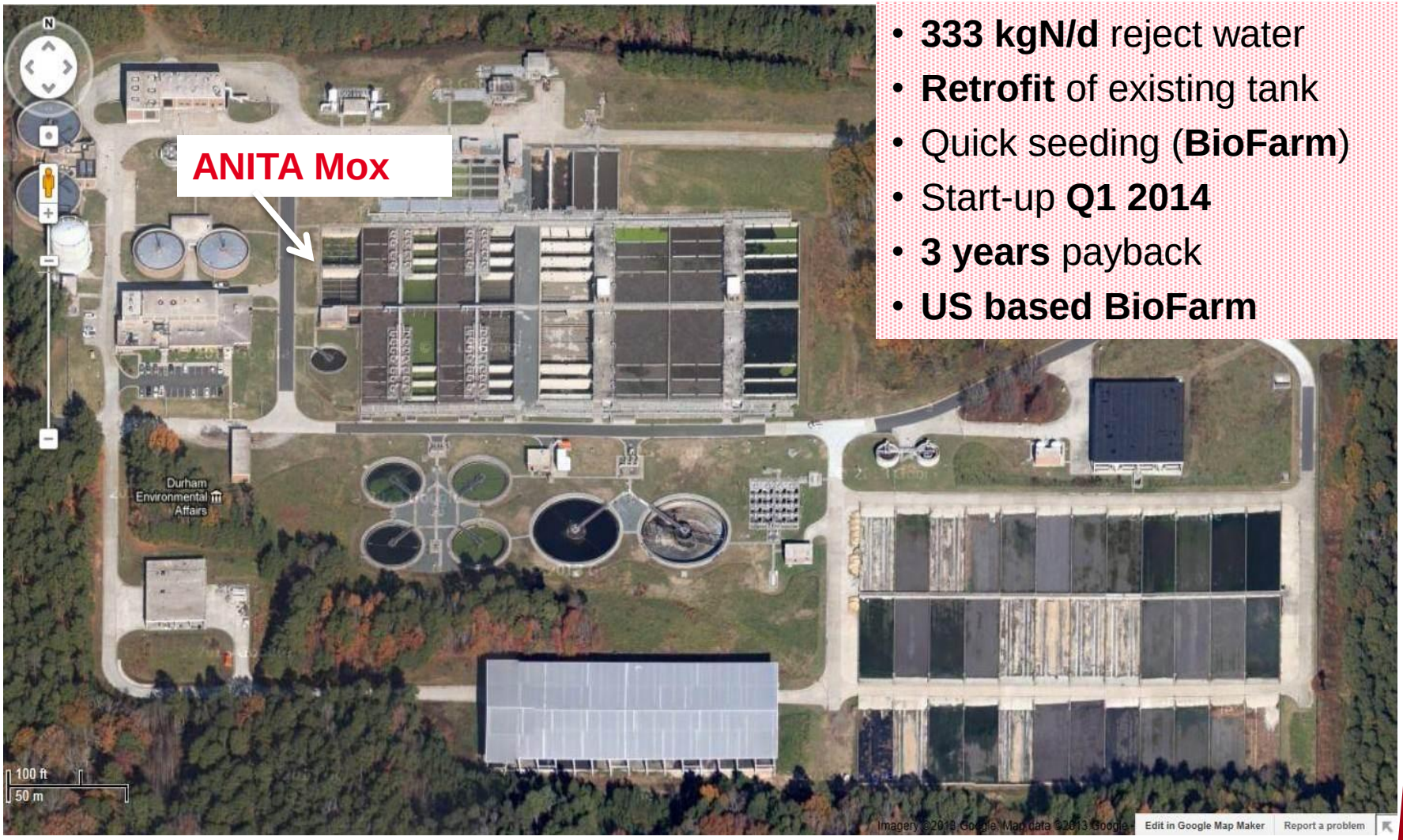
- **110 kgN/d** reject from co-digester
- **140 m³** (new tank)
- Quick Seeding (**BioFarm**)
- Start-up **May 2013**

- 50 000 tons/year to BioPasteur® digester:
  - 45% of DS from wastewater sludge
  - 35% of DS from organic household waste
  - 20% of DS from organic industrial waste

ANITA™Mox – James River WWTP, Newport News, VA US

- **250 kgN/d** reject water
- **Retrofit** of existing tank
- Quick seeding (**BioFarm**)
- Start-up **Q3 2013**
- Existing **Hybas™** system 60,200m³/d

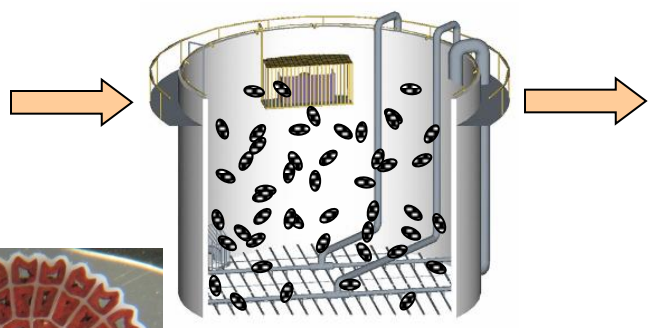
ANITA™ Mox – South Durham, North Carolina US

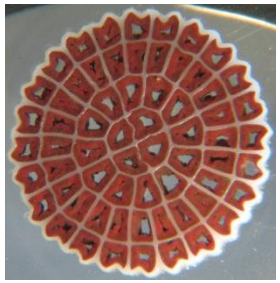


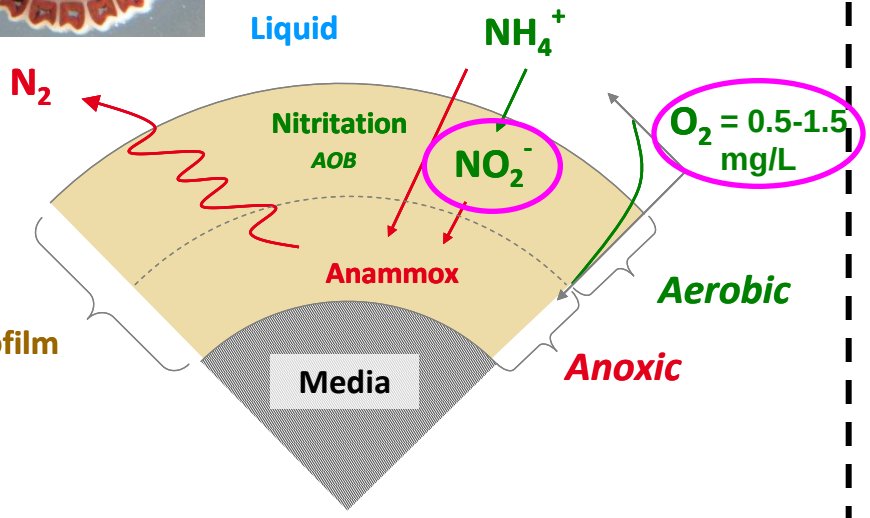
- **333 kgN/d** reject water
- **Retrofit** of existing tank
- Quick seeding (**BioFarm**)
- Start-up **Q1 2014**
- **3 years** payback
- **US based BioFarm**

New Development – IFAS configuration

MBBR

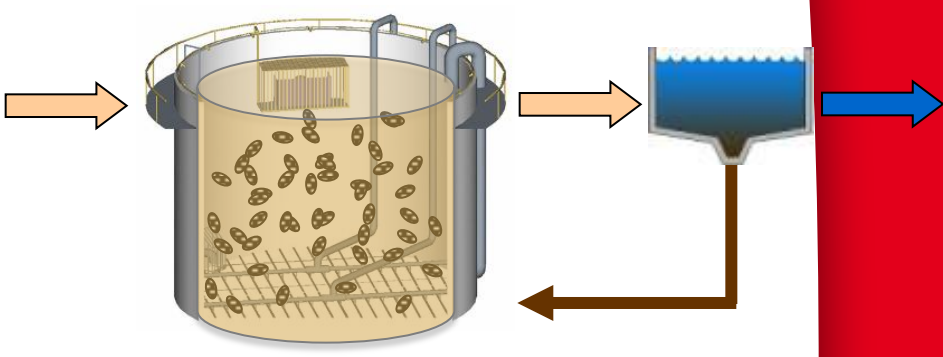


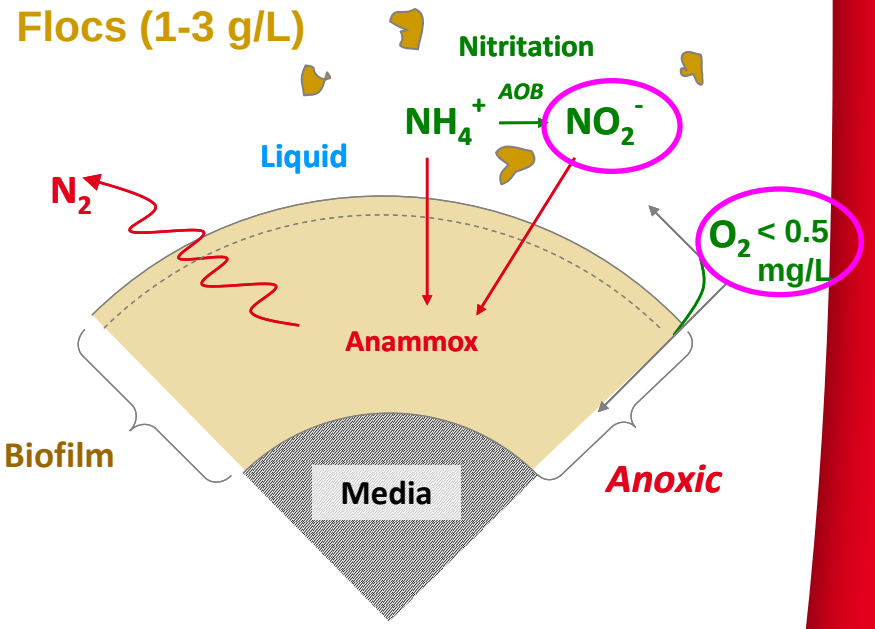




AOB in biofilm = NO_2^- limitation

IFAS





AOB in flocs = less NO_2^- limitation

Bench-scale trial – IFAS and MBBR

A Influent

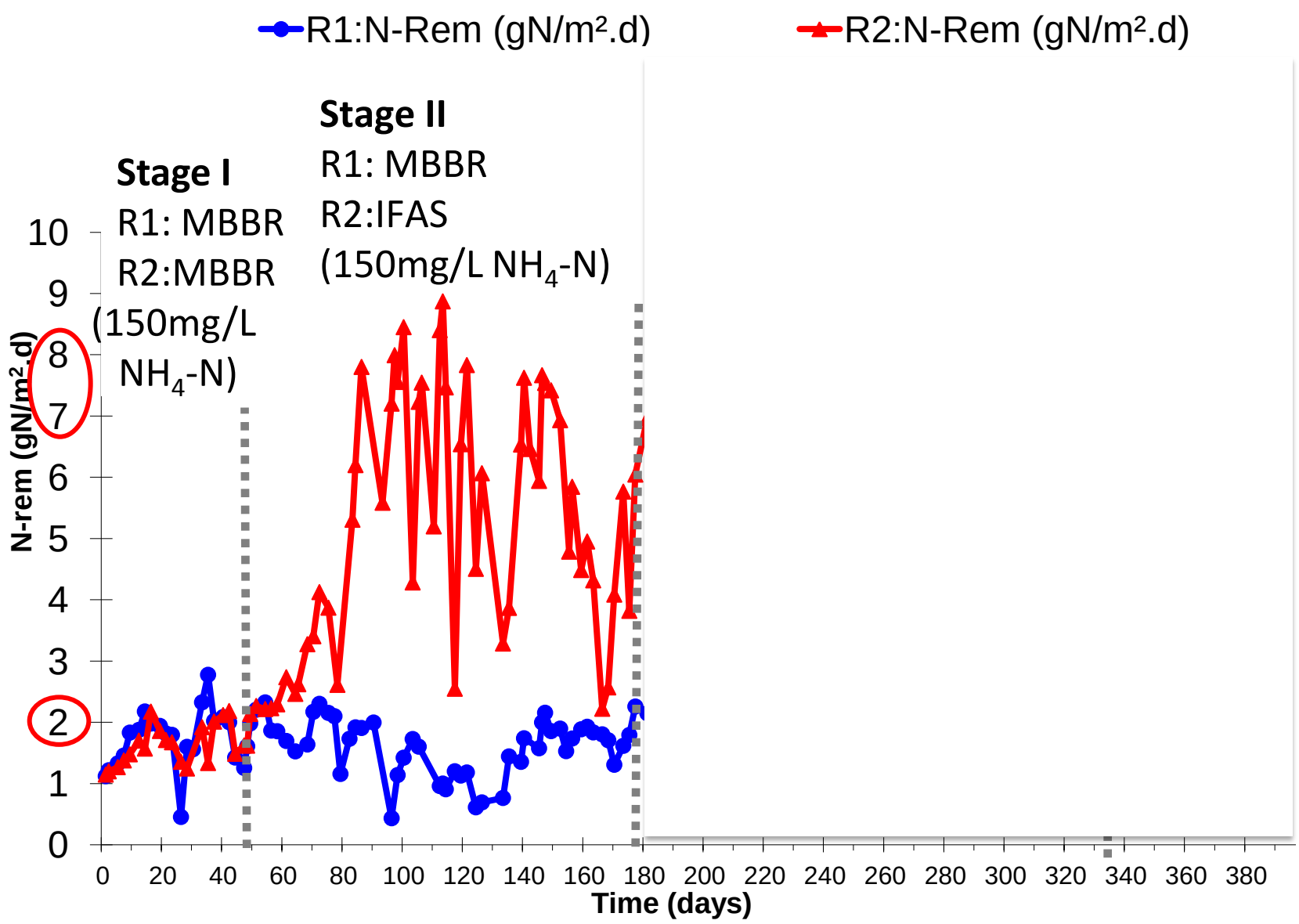
- AD Sidestream
- NH_4= 900 mgN/L
- tCOD= 400 mg/L
- BOD = 30 mg/L
- tCOD/N = 0.4
- sbCOD/N = 0.25

B Conditions

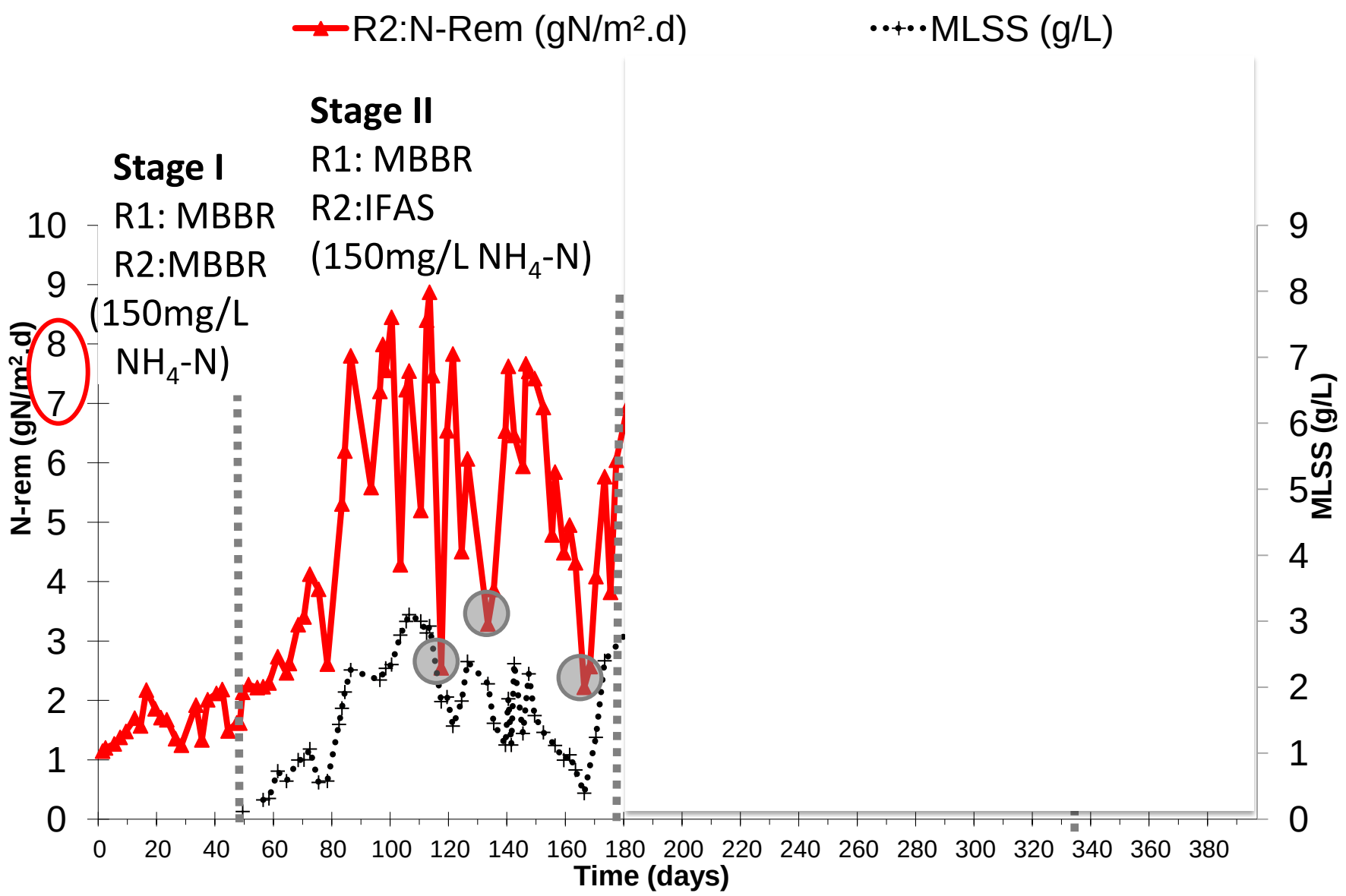
- 30 °C
- 43 % K5 carrier
- Volume reactor = 7 L
- $D.O._{IFAS}$= 0.2 mg O_2/L
- $D.O._{MBBR}$= 1.0 mg O_2/L

IFAS MBBR

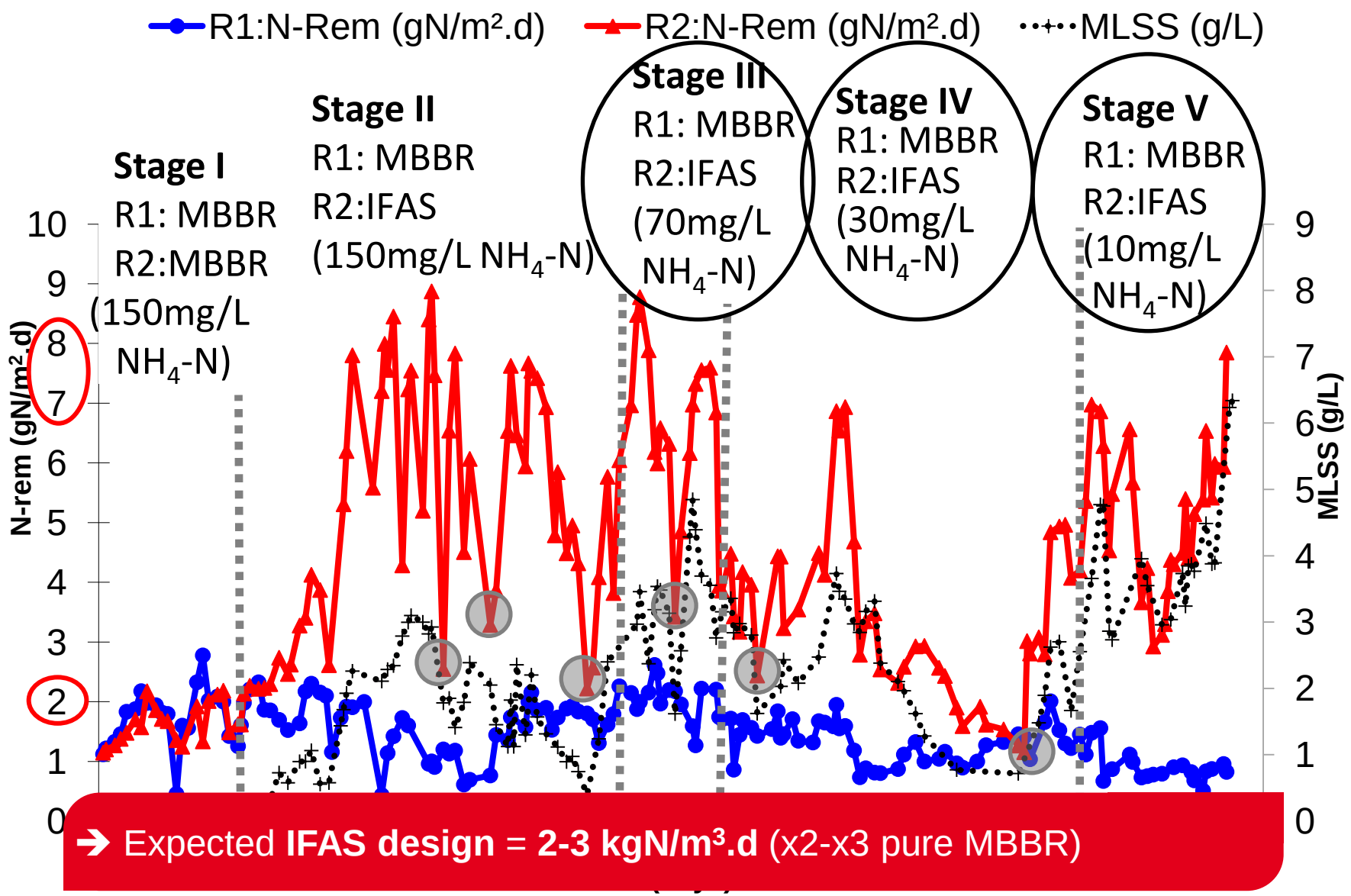
Hybas™ ANITA™Mox – Bench-scale



Hybas™ ANITA™Mox – Bench-scale



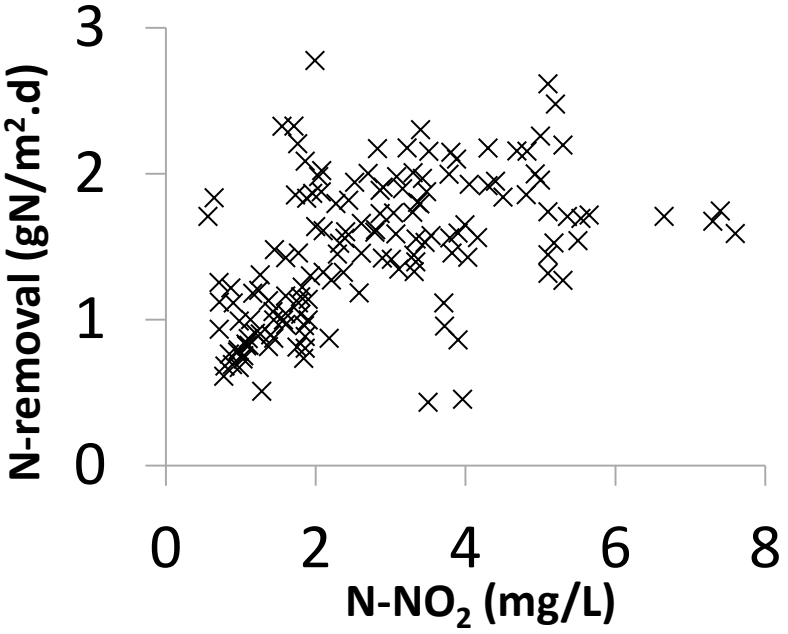
Hybas™ ANITA™Mox – Bench-scale



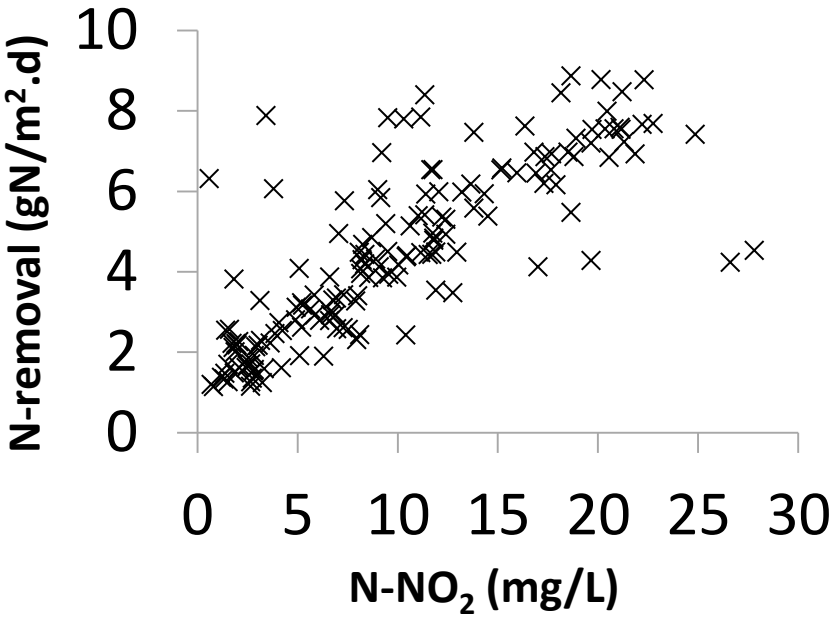
➔ Expected **IFAS design** = **2-3 kgN/m³.d** (x2-x3 pure MBBR)

Hybas™ ANITA™Mox – Bench-scale

MBBR



IFAS

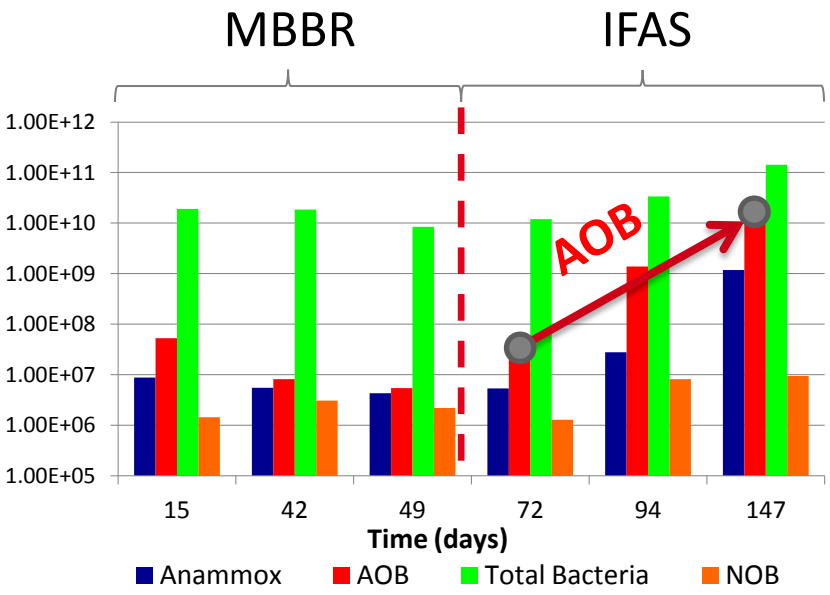


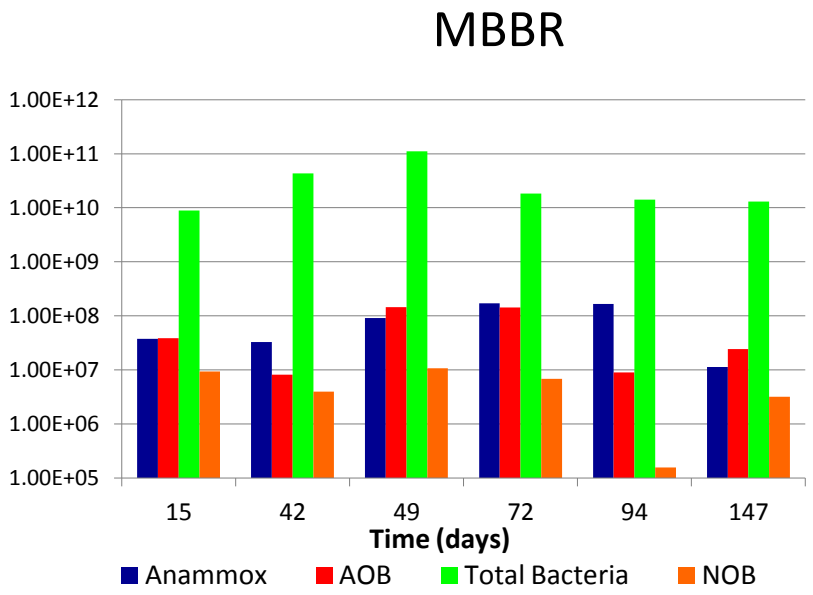
- ➔ Higher NO_2 concentrations in IFAS
- ➔ Higher N-removal rates with higher NO_2 concentrations
- ➔ Optimum NO_2 level depends of hydrodynamics condition

Hybas™ ANITA™Mox – Bench-scale

- **qPCR** : Evolution (Anammox, AOB, NOB and total Bacteria)

Suspended solids composition (MLSS)





1. Stable SS composition in MBBR
2. Augmentation of Biomass in IFAS
3. **Higher increase of AOB in IFAS (x1000!)**

Hybas™ ANITA™Mox – Bench-scale

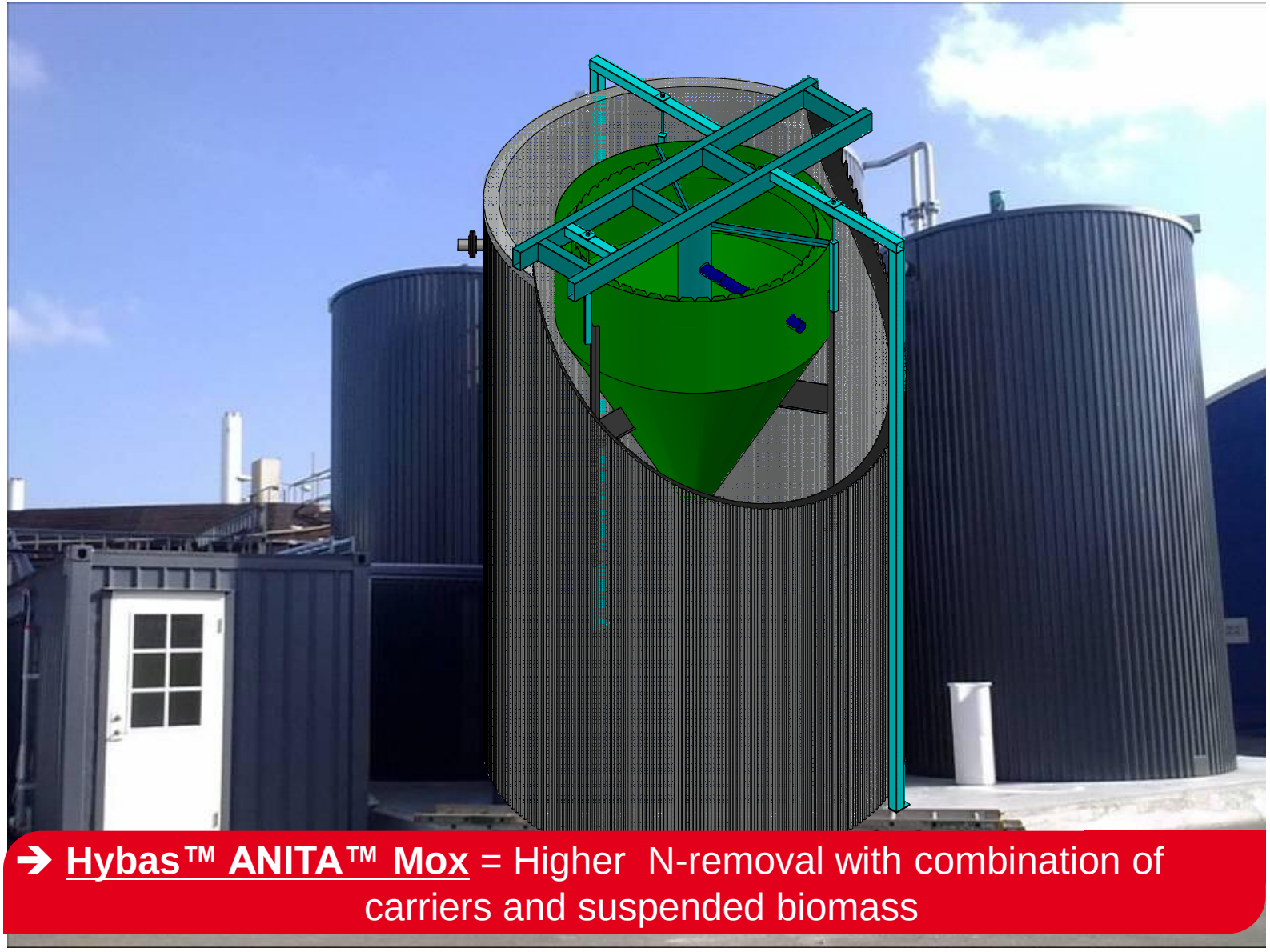
- **qPCR** : Evolution (Anammox, AOB, NOB and total bacteria)

Biomass repartition IFAS vs MBBR

	Biofilm	MLSS
→ **Anammox**		
Mode MBBR	*99%*	*1%*
Mode IFAS	*96 %*	*4%*
→ **AOB**		
Mode MBBR	*99%*	*1%*
Mode IFAS	*7%*	*93%*
→ **Total biomass**		
Mode MBBR	*92%*	*8%*
Mode IFAS	*52%*	*48%*

x 1 000 in IFAS

Hybas™ ANITA™Mox – IFAS configuration



➔ **Hybas™ ANITA™ Mox** = Higher N-removal with combination of carriers and suspended biomass

New Development – Mainstream N-removal

- ANITA™ Mox Pilot trial on **BOD-treated WW:**
  - **After BOD AS (Sweden)**
  - **After UASB (Middle East)**

- 3 different systems tested:
  - **Pure MBBR**
  - **IFAS**
  - **Sequenced treatment** of reject water and BOD-treated WW

ANITA™ Mox – Applications (MBBR & IFAS)

- **Municipal :**

  Sidestreams:

  - Anaerobic Digested Sludge centrate — **validated**
  - Thermal Hydrolysis* + AD centrate — **validated**

  Mainstream: ***(IFAS = easy retro fit)***

  - Post anaerobic (UASB) — **under evaluation**
  - Post high-rate BOD-stage — **under evaluation**

- **Industrial :**

  - Landfill Leachates (old) — **validated**
  - Post anaerobic from Bio-composting (COD/N=2) — **validated**
  - Micro-electronic / Semi-cond — **validated**
  - Other Post anaerobic effluent (slaughterhouse, F&B) — **under evaluation**

* *(Biothelys™, Exelys™, Cambi™)*

ANITA™Mox – Conclusion

- **Stable** and **robust**
- **Low OPEX + C-footprint :**
  - - 60% O_2 / no COD dosing / 1.4-1.7 kWh/kgN_{rem} / N_2O < 0.5%
- **Efficient** aeration control
  - Continuous aeration → no mixer / low N_2O
  - Keep NO_3 < 11% → no NOB (MBBR & IFAS)
- **N-removal** performances **:**
  - **MBBR** = **>1 $kgN_{rem}/m^3.d$** (Sidestream)
  - **IFAS** = **2-3 $kgN_{rem}/m^3.d$** (Sidestream)
- **BioFarm** seeding strategy = **Quicker Start-up**
- **6 references :**
  - Malmö WWTP (Sweden) → **200 kgN/d** reject water *2010*
  - Växjö WWTP (Sweden) → **430 kgN/d** reject water *2012*
  - Holbæk WWTP (DK) → **120 kgN/d** reject water + leachate *2012*
  - Grindsted WWTP (DK) → **110 kgN/d** co-dig. sludge + food waste *May 2013*
  - James River WWTP (USA) → **253 kgN/d** reject water *Aug 2013*
  - South Durham WWTP (USA) → **333 kgN/d** reject water *late 2013*

THANK YOU !!