Mainstream Deammonification Using The ANITA™ Mox Process

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   - Paris
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1. Introduction to ANITA™ Mox
Deammonification “Short Cut” Cycle for Nitrogen Removal

1/2 Nitrification

Nitritation

Nitratation

Nitrification

NO₂⁻

AOB

55%

55%

NH₄⁺

Aerobic

-60% O₂

Anoxic

NH₄⁺

-100% COD

Denitrification

Heterotrophs

N₂ + NO₃⁻⁻

89% 11%

COD

Heterotrophs

55%

45%

O₂

NO₂⁻⁻

NO₂⁻⁻

NO₃⁻⁻

Heterotrophs

O₂

Deammonification “Short Cut” Cycle for Nitrogen Removal

-100% COD

Anoxic

45%
When compared to conventional N-DN:

- **Deammonification Advantages**
  - 60% less O₂ required
  - No external carbon needed
  - Reduced sludge production

- **Small Footprint**
  - Compact footprint
  - MBBR → smaller tanks
  - IFAS → even smaller tanks than MBBR
  - Re-use existing tanks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ANITA™ Mox</th>
<th>Conventional Nitrogen Removal</th>
<th>Reduction from ANITA™ Mox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen Requirement (lb O₂ / lb N)</td>
<td>1.9</td>
<td>4.6</td>
<td>60%</td>
</tr>
<tr>
<td>Methanol Consumption (lb / lb N)</td>
<td>0</td>
<td>3.0</td>
<td>100%</td>
</tr>
<tr>
<td>Sludge Production (lb VSS / lb N)</td>
<td>0.1</td>
<td>0.5 – 1.0</td>
<td>50 – 90%</td>
</tr>
</tbody>
</table>
Introduction to ANITA™ Mox

- ANITA Mox is a biofilm process
  - Bacteria Retained by Media and Screens
  - Media has a high protected surface area per unit volume
  - Anammox is retained on the media
- Robust Process
  - Tolerates Variability in Dewatering Schedules and Dewatering Starts/ Stops
  - Tolerates High TSS and Swings in TSS
  - Tolerates High Polymer Residual
  - Tolerates Wide Range of DO
  - Tolerates Wide Range of pH
  - Tolerates High NO₂-N Residual
Deammonification – “Sidestream” vs. “Mainstream”

Mainstream Treatment:
- Screening
- Degrifting
- Primary Clarifier
- Biological Treatment
- Clarifier
- Discharge

Sidestream Treatment:
- Refuse
- Sand, grease
- Thickener
- Anaerobic Digester
- Gas Holding
- CHP
- Sludge Disposal
- Dewatering
Introduction to ANITA™ Mox

- U.S. Installations – Sidestream
  - James River TP, VA (HRSD) (2014)
  - South Durham WRF, NC (2015)
  - Egan WRP, Chicago, IL (MWRDGC) (2016)
  - Denver Metro, CO (2017)

- Europe Installations – Sidestream
  - Malmo, Sweden (2010)
  - Växjö, Sweden (2011)
  - Holbæk, Denmark (2012)
  - Grindsted, Denmark (2012)
  - Industrial Client (F&B), Poland (2015)
  - Locarno, Switzerland (2015)
  - Arla Foods (Dairy), United Kingdom (2015)
  - Viikinmäki (near Helsinki), Finland (Large Scale Pilot) (2015)
  - Borås, Sweden (2016)
  - Stockholm Vatten-Bromma, Sweden (2016-17)
Introduction to ANITA™ Mox

- MBBR = Moving Bed Biofilm Reactor
  - Use of polyethylene media to foster and house biofilm for wastewater treatment
  - Biological treatment is accomplished on the media in the biofilm

- IFAS = Integrated Fixed Film Activated Sludge
  - Use of return activated sludge (RAS) to create an environment of both biofilm and suspended biomass for wastewater treatment
  - Biological treatment is accomplished in both the biofilm and in the suspended biomass
Introduction to ANITA™ Mox

MBBR

AOB in biofilm = NO₂⁻ limitation

IFAS

AOB in flocs = less NO₂⁻ limitation
ANITA™ Mox – IFAS Configuration

- 2 types of sludge:
  - *Nitrifiers* + *OHOs* = flocs
  - *Anamox* = biofilm
- More NO₂⁻ & Lower DO
- Less sensitive to incoming COD
- More compact (=higher rate):
  - *Greenfield project*
  - *Retrofit in small tank*

→ Veuillet et al. (2014) *Wat. Sci. Tech*
→ Veuillet et al. (2014) *IWA WWC Lisbon*

- Mainstream Application:
  - *Boost AOB while suppressing NOB*
  - *Retrofit into existing AS*

AOB in flocs = less NO₂⁻ limitation

0.2-0.5 mg/L
2. Mainstream ANITA™ Mox
Mainstream ANITA™ Mox – Energy-Neutral WWTP

C removal → Energy positive

- COD of WW → Biogas production:
  - Primary sludge
  - Organic Sludge from C-stage

- Remove remaining N with ANITA Mox process with low COD/N

Energy production (+++)
Mainstream ANITA™ Mox – 1-Stage IFAS

C removal → Energy positive

N-removal (without COD)

Lower Energy consumption (- - -)

CEPT

High rate AS

MBBR-C

Biofilter

Energy production (+++)

UASB

THP

Digester

IFAS ANITA Mox (Mainstream)

ANITA Mox (Sidestream)
Mainstream ANITA™ Mox – 2-Stage MBBR

C removal \(\rightarrow\) Energy positive

N-removal (without COD)

NH\(_4\) \(\rightarrow\) NO\(_2\)

MBBR (nitritation)

NH\(_4\) + NO\(_2\) \(\rightarrow\) N\(_2\)

ANITA Mox (anoxic)

New «Z» media

Energy production (+++)

CEPT

Biofilter

MBBR-C

UASB

THP

Digester
3. Mainstream ANITA™ Mox Pilots
Mainstream ANITA™ Mox Pilots – Paris

**Primary Treatment**
- Lamella Clarifier
- No Chemical

**C-stage**
- MBBR (2m³, 30% fill)
- Drumfilter (0.4m², 40μm)

**N-stage**
- Hybas (2m³, 40% fill)
- Clarifier (1.5m²)
- Temp = 15-23°C

**Process Flow**
- Primary Treatment
- C-stage
- N-stage
Paris Pilot – MBBR-C Influent (Primary Effluent)

CODt / NH4 = 6-9
CODs / NH4 = 2.5-4
Paris Pilot – MBBR-C Effluent

- CODt / NH₄ = 3-5
- CODs / NH₄ = 1.5-2
- 60-70% CODs removal

CODt, CODs, (mg/L)
NH₄ (mgN/L), TSS (mg/L)

Time (days)
Paris Pilot – Hybas™ ANITA Mox N-removal

NH₄ load, NH₄ removal (gN/m²/day)

Time (days)

Temperature (°C)

NH₄ removal = 1.2 gN/m².d @ 23° / 0.8 gN/m².d @ 18° / 0.6 gN/m².d @ 15°
Sequenced aeration:

- $\text{TN}_{\text{out}} \approx 10 \text{ mgN/L}$
- $80\%$ TN removal
- $\% \text{NO}_3/\text{NH}_4 < 10\%$

Lost MLSS – Aeration issue

Sequenced Aeration

Paris Pilot – TN in Final Effluent
Paris Pilot – Ongoing Trial: No C-stage

Primary treatment:
- Primary Clarifier
- No Chemical

C-stage:
- MBBR (2m³, 30% fill)
- Drumfilter (0.4m², 40μm)

N-stage:
- Hybas (2m³, 40% fill)
- Clarifier (1.5m²)
- Temp = 16-23°C
Mainstream ANITA™ Mox Pilots – Toulon
Mainstream ANITA™ Mox Pilots – Toulon

C removal → Toulon WWTP (80 000 PE)

COD = 90 mg/L
BOD = 20 mg/L
TSS = 30 mg/L
Mainstream ANITA™ Mox Pilots – Toulon

C removal ➔ Toulon WWTP (80 000 PE)

N removal ➔ Pilot ANITA Mox

Primary Chemical Addition

Biostyr-C

Reject water

Hybas™ ANITA™ Mox (Mainstream)

TN=10 mg/L

Primary

Chemical Addition

Digester

Mainstream ANITA™ Mox Pilots – Toulon

C removal ➔ Toulon WWTP (80 000 PE)

N removal ➔ Pilot ANITA Mox

Primary Chemical Addition

Biostyr-C

Reject water

Hybas™ ANITA™ Mox (Mainstream)

TN=10 mg/L

Primary

Chemical Addition

Digester
Digester

C removal $\rightarrow$ Toulon WWTP (80 000 PE)

N removal $\rightarrow$ Pilot ANITA Mox

Hybas™ ANITA™ Mox (Mainstream)

Primary Chemical Addition

Reject water

Chemical Addition

Digester
Toulon Pilot – $\text{NH}_4\text{-N}_{\text{in}}$, $\text{NH}_4\text{-N}_{\text{out}}$, $\text{TN}_{\text{out}}$

After Biostyr-C

Directly after Primary

Lost MLSS
Toulon Pilot – NH₄ Load and Removal

After Biostyr-C

Directly after Primary

NH₄ Load

NH₄ Removal

Temp (°C)

Lost MLSS

NH₄ load, NH₄ removal (gN/m².d)

Days

Temperature (°C)
4. Conclusions and Questions
ANITA Mox™ is Veolia’s deammonification process based upon a MBBR or IFAS platform

- *Biofilm systems have been shown to provide robust treatment and secure anammox retention*

Based upon ongoing Mainstream ANITA™ Mox Pilots at Paris and Toulon:

- *Good effluent quality (~10 mg/L TN) without downstream polishing for N-removal*
- *Different configuration possible after C-stage or directly after Primary*

Further optimization and bioaugmentation from Sidestream to Mainstream (1-Stage or 2-Stage) are expected to improve the robustness, the final effluent quality and the start-up period for Mainstream ANITA Mox
Conclusions and Questions

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