Aerobic Granular Sludge Technology

Tatiana Mazzei
Project Applications Engineer
Overview

• History of Aerobic Granular Sludge
• What is Aerobic Granular Sludge?
  – Attributes
  – Granule Formation
• AquaNereda Process & Operation
• Comparison of AquaNereda vs. Other Processes
• Demonstration Facility and Pilot Units
• Installations Worldwide and in the U.S.
• Summary
History of Aerobic Granules
From The Netherlands to the United States

Aerobic Granule Research Begins

First Granules in Laboratory

First Industrial AGS Plant (Netherlands)

First Municipal AGS Plant (South Africa)

AASI North America Licensee

Construction of Demo Facility Begins (Rockford, IL)

First AquaNereda Pilot in North America

First North American AGS Plant Start-up (Foley, AL)

Demo Facility Operation Begins

78 Nereda® Plants Worldwide
Nereda® Plants Worldwide
AquaNereda® in the U.S.

Rockford, IL
Capacity (Ave) 0.2 MGD
Capacity (Max) 0.4 MGD

Wolf Creek, AL
Capacity (Ave) 3.5 MGD
Capacity (Max) 6.0 MGD

Maui, HI
Capacity (Ave) 0.08 MGD
Capacity (Max) 0.08 MGD

Whitefish, MT
Capacity (Ave) 2.0 MGD
Capacity (Max) 6.0 MGD

Idaho Springs, CO
Capacity (Ave) 1.0 MGD
Capacity (Max) 2.0 MGD

Wolcott, KS
Capacity (Ave) 2.0 MGD
Capacity (Max) 6.0 MGD
Aerobic Granular Sludge Technology
Technical Overview
Granules making up aerobic granular activated sludge are to be understood as aggregates of microbial origin, which do not coagulate under reduced hydrodynamic shear, and which subsequently settle significantly faster than activated sludge flocs.

- True microbial biomass
- Aerobic granular sludge’s SVI5 comparable to SVI30 of conventional activated sludge
- Minimum particle diameter of 200 μm
Aerobic Granular Sludge
Conventional Activated Sludge vs. Granule Structure

Conventional Activated Sludge

Aerobic Granular Sludge
**Aerobic Granular Sludge**

Conventional Activated Sludge vs. Granule Structure

### Conventional Activated Sludge
Mixed Microbial Community

### Aerobic Granular Sludge
Layered Microbial Community

**Source:** engineersjournal.com
FISH Analysis
(Fluorescence In Situ Hybridization)

**GAO:** Glycogen Accumulating Organism
**NSO:** Nitrifying Organisms
**PAO:** Phosphate Accumulating Organisms
Aerobic Granular Sludge

Granular Structure

• Granules are not perfectly spherical
  – Complex structures with voids and channels
  – Allows penetration of nutrients into larger particles

**Aerobic Granular Sludge**

**Settleability**

- Excellent settling properties
- Increased MLSS

![AGS and CAS samples with settled sludge and clear water](image)

**AGS**
8 g/l or more

**CAS**
4 g/l

**SVI$_5$**
Granule Formation
Selection Mechanisms

1. Hydraulic selection for fast-settling particles
2. Biologic selection of EPS-forming microorganisms
Granule Formation

Hydraulic Selection

- Selective wasting
- Wash out smaller particles
- Dense granules settle faster than CAS
- Decreased settling time
Granule Formation

Biologic Selection

• Select for PAOs which secrete EPS
• EPS is the chemical backbone of the granule
• Dense bacterial gathering allow rapid settling

Granule Formation
Biologic Selection

• Granules are settled at the bottom of the reactor

• Influent is introduced into the granule bed
  – High F/M ratio

• Anaerobic conditions
AquaNereda®
Operational Description
Influent -> Screening and grit for disposal -> Biological Processes

Primary Processes:
- Solids Handling

Secondary Processes:
- Filtration

Tertiary Processes:
- Membranes
- Disinfection

Outflows:
- Agricultural
- Industrial and Residential Reuse
- Direct Discharge
AquaNereda® Technology
Process Overview

- Simple, one-tank reactor concept
- No secondary clarifiers
- Enhanced biological nutrient removal
- Timed cycle flexibility
- No sludge recirculation
AquaNereda® Technology
Simplified Flow Diagram

Influent → Grit Removal and Screening → Pre-EQ (if needed) → AGS Reactors → Post-EQ Tertiary Filtration (if needed) → Effluent

- Supernatant
- Excess Sludge
- Thickened Sludge
- Side Stream Sludge Thickening
- Digestion
- To Sludge Dewatering
AquaNereda® Technology
Process Cycle
AquaNereda® Characteristics

• Excellent settling properties
• Up to 75% smaller footprint
• Up to 50% energy savings
• Increased capacity
• Sustainable, robust technology
• No support media
• No bulking sludge
• Chemical savings

Source: T.R. Devlin Aerobic Granular Sludge Presentation
AquaNereda® Characteristics
Up to 75% Footprint Reduction

Garmerwolde WWTP, NL
AquaNereda® Characteristics

Up to 50% Energy Savings

Garmerwolde WWTP, NL
### AquaNereda® Characteristics

**Significant Chemical Savings**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Unit</th>
<th>A/B system</th>
<th>Nereda</th>
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<tr>
<td>Fe</td>
<td>ton</td>
<td>119</td>
<td>130</td>
<td>25</td>
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<tr>
<td>Coagulant</td>
<td>ton PEactive</td>
<td>39</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Flocculant</td>
<td>ton PEactive</td>
<td>8.4</td>
<td>7</td>
<td>-</td>
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<tr>
<td>PAC</td>
<td>kgal</td>
<td>38</td>
<td>37</td>
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<tr>
<td>C-source</td>
<td>kgal</td>
<td>189</td>
<td>159</td>
<td>-</td>
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</table>

In 2015, 8 ton of Fe was used during storm events.

In 2016, the operator better managed the system and used no Fe.

Data from Garmerwolde WWTP, NL
**AquaNereda® Technology**

**Process Robustness**

- Displays robustness during less-favorable conditions:
  - Salinity fluctuations
  - Toxic shock
  - Chemical spikes
  - pH fluctuations
  - Load variations

Conventional activated sludge and aerobic granular sludge with shock addition of 5,000 ppm NaCl after 5 min of settling.
Comparison
5-Stage BNR System

Comparison to Typical Multi-Stage BNR System

1Q RAS

Anaerobic Reactor
Primary Anoxic
Primary Aerobic
Secondary Anoxic
Secondary Aerobic

1Q
3-5Q
1Q
Process Comparison

Footprint

- BNR
- SBR
- Ballasted Floc
- IFAS
- MBR

Footprint

100%
50%
60% - 45%
60%
25%
25%

Note: Ballasted Floc footprint will depend on Process retrofitted
Process Comparison

Energy

Note: Ballasted Floc Energy consumption will depend on Process retrofitted
Process Comparison
20-Year Life Cycle Cost

AquaNereda®
Operations
AquaNereda® Operations
Typical System Components

- Aeration system
- Pumps
- Valves
- Internal process piping
- Wier assembly
- Instrumentation
- Controls
AquaNereda® Operations
Mechanical/Maintenance

Inside the Tank:

– Fine air bubble diffusers

Outside the Tank:

– Pumps
– Valves
– Blowers
– Instrumentation
  • Probes (pH, DO, ORP, TSS)
  • Analyzers (Phosphorus, Ammonia)
AquaNereda® Operations
Process/Laboratory

Operations:  
- SVI
- MLSS
- Sieve analysis (bi-weekly)

Laboratory:  
- BOD/COD
- Ammonia
- Phosphorus
- TSS
AquaNereda® Demonstration Facility
Rockford, IL USA
AquaNereda® Demo Facility
Rockford, IL
AquaNereda® Demo Facility Reactor

• Capacity: 200,000 gal/day
• Volume: 94,250 gallons
• Dimensions: 30 ft (L) x 20 ft (W)
• Depth: 21.0 ft
• Sludge Holding Tank: 15,000 gallons
AquaNereda® Demo Facility
Average Performance Since Start-up

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent (mg/L)</th>
<th>Effluent (mg/L)</th>
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<tbody>
<tr>
<td>COD</td>
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<tr>
<td>sCOD</td>
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<tr>
<td>BOD$_5$</td>
<td>150</td>
<td>5</td>
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<tr>
<td>TSS</td>
<td>144</td>
<td>9</td>
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<tr>
<td>Total N</td>
<td>26</td>
<td>4.9</td>
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<tr>
<td>NH$_4$-N</td>
<td>14</td>
<td>0.6</td>
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<tr>
<td>Total P</td>
<td>2.55</td>
<td>0.5</td>
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<tr>
<td>UVT</td>
<td>36%</td>
<td>76%</td>
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## AquaNereda® Demo Facility
### High Load Operation

<table>
<thead>
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<th>Parameter</th>
<th>Influent (mg/L)</th>
<th>Effluent (mg/L)</th>
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</thead>
<tbody>
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<td>COD</td>
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<td>41</td>
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<tr>
<td>TSS</td>
<td>210</td>
<td>10</td>
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<tr>
<td>TN</td>
<td>58.8</td>
<td>6.0</td>
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<tr>
<td>Total P</td>
<td>3.4</td>
<td>0.44</td>
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</tbody>
</table>

Flow: 0.3 - 0.35 MGD
AquaNereda®
US Installations
AquaNereda® Projects

U.S. Installations

• Wolf Creek, Alabama
  • Start-up: Jan. 2020
• Whitefish, Montana
  • Detailed Design
• Maui Airport
  • Detailed Design
• Idaho Springs, Colorado
  • Detailed Design

Wolf Creek - September 2018
Summary
AquaNereda® Summary

- AGS reduces footprint, increases capacity and reduces energy
- Achieves BNR and Bio-P removal
- Easy to operate
- Full-scale plants, demo facility and pilots to assist in design validation and regulatory approval
- Installations around the world, with many coming soon to the U.S.
Questions?