New Perspectives for wastewater treatment

Andreas.Giesen@RHDHV.com
Our Company

- Global consultancy, design, engineering, technology and project management service provider
- Leader in sustainability and innovation
- Nr 1 in The Netherlands
- Top 10 of independently owned, non-listed companies
- Top 40 worldwide
- Turnover around USD 1 Billion
- 7,000 experienced and specialised staff
- 100 offices in 35 countries
- From Consultancy to Design&Build and O&M
“Sewer pit” of Europe

In the past:
- Heavy pollution of surface water
- Threat to society and industry
- Focus on wastewater treatment
Better and more cost-effective

1954 oxidation ditch

Carrousel®
A Royal HaskoningDHV product
Better and more cost-effective

UASB-Biopaq
a Paques product

Carrousel®3000: deep tank design & zero-nuisance
A Royal HaskoningDHV product
For better P removal

BCFS for enhanced bio-P
A Royal HaskoningDHV product

Crystalactor for P-recovery
A Royal HaskoningDHV product
For additional N removal

Sharon
A Grontmij product

Anammox
A Paques product
Current developments

Energy Factory
Energy positive treatment

Raw Material Factory
Recovery of products

Afvalwater zit vol grondstoffen...
Nereda® in a nutshell

- Excellent and robust settling properties
- Lower CAPEX and OPEX
- Lower energy consumption
- Compact
- Easy to operate
- Sustainable

Biological wastewater treatment technology using Aerobic granular biomass
Nereda® Technology

Transformation biomass structure
Aerobic Granular Biomass

- Excellent settling properties
- Pure biomass
- No support media
- High MLSS levels (up to 15 g/L)
- Reliable and stable operation
- No bulking sludge
**Oxygen gradient in granule**  
**simultaneous COD, P and N-removal**

- **Heterotrophic organisms**
- **Ammonium oxidising organisms**

**Anaerobic zone:**
- Nitrate reduction to nitrogen gas
- Phosphate removal

\[ \text{COD} + \text{NO}_x + \text{PO}_4^{3-} \rightarrow \text{N}_2 + \text{CO}_2 + \text{H}_2\text{O} + \text{poly-P} \]

**Aerobic zone:**
- Biological oxidation
- Ammonium oxidation to nitrate

\[ \text{COD} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]
\[ \text{NH}_4 + \text{O}_2 \rightarrow \text{NOx} \]

Transport by diffusion, not by pumping
BNR in activated sludge requires many compartments and circulation flows.
Nereda® process cycle

- Simple one-tank concept
- No clarifiers
- No moving decanter
- No mixers
- Extensive biological COD, N- and P-removal
- Low energy consumption
- Easy operation
Principle of Nereda®

Activated sludge

Aerobic granular biomass

Courtesy Delft University of Technology
**Key advantages Nereda**

- **75% smaller footprint:**
  - high biomass concentration
  - no selectors, no anaerobic tanks, no clarifiers

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activated sludge with bio-P

Nereda

Area Requirement (m²)
Key advantages Nereda

- **75% smaller footprint:**
  - high biomass concentration
  - no selectors, no anaerobic tanks, no clarifiers

- **>25-35% energy savings:**
  - less rotary equipment
  - efficient aeration
Key advantages Nereda

- 75% smaller footprint:
  - high biomass concentration
  - no selectors, no anaerobic tanks, no clarifiers

Area Requirement (m²)

- >25-35% energy savings:
  - less rotary equipment
  - efficient aeration

- lower construction & operation costs
History

It all started with a good discussion and collaboration between two professors at an October Fest

Prof. Peter Wilderer
TU Munich

Prof. Mark van Loosdrecht
TU Delft
First industrial references

2005 cheese products

2006 ready-made food

2007 edible oil

2009 ready-made food
History

- Mid '90's Research by Delft University of Technology (DUT)
- 1995 Stable granulation in lab
- 2000 close co-operation DUT / DHV
- 2002 Stable granulation, extensive N- and P-removal in DUT lab
- 2002 Feasibility study showed great potential
- 2003 – 2005 Large pilot-research at Ede STP
- 2005 Start-up industrial launching customer
- 2006 Industrial units
- Start Municipal National Nereda Research
- 2006 / 2008 Design/construction municipal demo units
- 2010 construction first Dutch full scale municipal plant
Installed base: The Netherlands – Portugal – South Africa

Cheese speciality industry
Convenient food industry
Edible oil industry (SBR retrofit)
Convenient food industry
STP Epe | 59.000 pe | 1.500 m3/h
STP Vroomshoop | 25.000 pe | 1.265 m3/h
STP Dinxperlo | 15.730 pe (construction)
STP Lisbon | 3 MLD (semi full-scale retrofit demo)
STP Gansbaai | 63.000 pe | 5 MLD
STP Stellenbosch | 40.000 pe | 5 MLD (construction)
STP Garmerwolde | 150.000 pe | 4.200 m3/h
STP Utrecht | 530.000 pe | 15.000 m3/h (demo in operation)

Pipeline: approx. 40, inclusive larger scale, in e.g. Australia, China, Brazil, India, Poland, UK
Frielas WWTP - description

• Design
  • P.E. = 700.000 p.e.
  • ADF = 70.000 m3/d
  • RWF = 6.000 m3/h
  • C removal + desinfection
    • COD < 125 mg/l
    • BOD$_5$ < 25 mg/l
    • TSS < 35 mg/l
    • Coliforms < 2000/100 ml

• Actual
  • P.E. = 250.000 p.e.
  • ADF = 50.000 m3/d
  • RWF > 6000 m3/h
Frielas WWTP - description

1. Screw pumps and screens
2. Grit, O&G removal
3. Lamella settlers
4. Screw pumps
5. Equalization basins
6. Complete mix activated sludge (A.S.)
7. Secondary settlers
8. Pumping and biofilters
9. UV disinfection
10. Gravity thickeners
11. Flotation thickeners
12. Anaerobic digesters
13. Biogas storage
14. Sludge dewatering

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Nereda® Demo - performance

The granules!
Nereda® vs AS – Settleability

SVI A.S. vs SVI Nereda

<table>
<thead>
<tr>
<th>AT1</th>
<th>AT2</th>
<th>AT3</th>
<th>AT4</th>
<th>AT5</th>
<th>Nereda</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SVI30 (ml/g)

1-May-12  21-May-12  10-Jun-12  30-Jun-12  20-Jul-12  9-Aug-12  29-Aug-12  18-Sep-12  8-Oct-12  28-Oct-12
Nereda® vs AS – Energy savings

Up to 50% considering also saving with settler and recirculation pumps operation
Future full scale Nereda® retrofit
Waterschap Veluwe | The Netherlands

- Replace existing sewage treatment plant
  - doubling capacity
  - from basic water quality (no BNR) to very stringent effluent demands
- targets of management
  - cost-effectiveness
  - reduce energy consumption
Replacement STP Epe

Existing STP
Activated sludge
33,000 p.e.
1,000 m³/h
Partial N-removal
Chemical P-removal

New situation
Aerobic granular sludge
59,000 v.e.
1,500 m³/h
Full N-removal
Biological P-removal
Since September 2011 on-line. Progressively increased feed. Within 4 months treating 100% of feed.

- Inaugurated on May 8, 2012
- Very good effluent quality (even at quite low temperature)
- Low energy consumption
- Sludge processing performs better than expected
- Plant operated by RHDHV and gradually handed-over to client.
- Old plant partly demolished.
## Epe performance

### Performance verification campaign March - May 2012 (flow proportional)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent mg/l</th>
<th>Effluent mg/l</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>879</td>
<td>27</td>
<td>96.9%</td>
</tr>
<tr>
<td>BOD</td>
<td>333</td>
<td>&lt; 2</td>
<td>&gt; 99.4%</td>
</tr>
<tr>
<td>$N_{Kj}$</td>
<td>77</td>
<td>1.4</td>
<td>98.1%</td>
</tr>
<tr>
<td>$NH_4^+$-N</td>
<td>54</td>
<td>0.1</td>
<td>99.8%</td>
</tr>
<tr>
<td>$N_{total}$</td>
<td>&lt; 4</td>
<td>&gt; 94.7%</td>
<td></td>
</tr>
<tr>
<td>$P_{ortho}$</td>
<td>5.8</td>
<td>0.26 *)</td>
<td>95.6%</td>
</tr>
<tr>
<td>$P_{total}$</td>
<td>9.3</td>
<td>0.3</td>
<td>97.2%</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>341</td>
<td>&lt; 5</td>
<td>&gt; 98.5%</td>
</tr>
</tbody>
</table>

*) < 0.02 mg P/l during second verification campaign
## Energy consumption per removed pollution equivalents
(of 150 g Total Oxygen Demand)

<table>
<thead>
<tr>
<th>Period</th>
<th>Energy consumption per removed pollution equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaranteed value</td>
<td>≤ 22.7 kWh/(PE.annum) @ full load</td>
</tr>
<tr>
<td>Actual</td>
<td>16.3 kWh/(PE.annum) @ full load</td>
</tr>
<tr>
<td></td>
<td>22.2 kWh/(PE.annum) @ actual load</td>
</tr>
<tr>
<td>Bench mark similar Dutch treatment plants with post treatment (Union of Dutch Water Boards 2009)</td>
<td>37.5 kWh/(PE.annum) @ actual load</td>
</tr>
<tr>
<td>Bench mark all STP’s (Union of Dutch Water Boards, 2009)</td>
<td>33.4 kWh/(PE.annum) @ actual load</td>
</tr>
</tbody>
</table>

**Energy consumption: 40% less than other Dutch STP’s with polishing filter**

while 2 m additional water head was incorporate to enable retrofit to conventional CAS
Garmerwolde STP

Waterschap Zuiderzijlvest

Upgrade of STP Garmerwolde (AB system) to accommodate for larger capacity and meeting nutrient standards

Consortium of contractors GMB/Imtech and their consultant Witteveen + Bos selects Nereda out of more than 20 options as most promising alternative

The addition of a 140,000 p.e. Nereda unit in parallel to the existing plant convincingly outcompeted a full range of different solutions provided by other bidders.
Garmerwolde STP

- Overall plant capacity: 375,000 p.e., 13,500 m³/h peak flow
- Nereda capacity: 140,000 p.e., 20 - 100 MLD (average 30) and 4,200 m³/h peak flow
- Nereda-reactors: 2 x 9,500 m³
- N_{total}=7 \text{ mg/l}; \ P_{total}=1 \text{ mg/l}
- No post treatment
- Start-up: June 2013
- Inaugurated: 8 October 2013
Garmerwolde STP

Started-up on small seed from Epe and activated sluge

Gradually increased feed flow

Meeting design flow in approx. 3 months (41% of total received wastewater)

Prompt performance on N-removal

Extensive bio-P performance in approx. 3 months

Approx. 60% lower energy consumption than A/B-system
Why Nereda is often the best choice

- Lowest construction costs
- Lowest operation costs
- Easy and reliable operation
- Lowest energy consumption
- Best environmental profile
- No chemicals for nutrient removal
- Minimal waste production
- Less impacted by unfavorable process conditions and toxicity
- Most modern technology
- Reuse of existing tanks often possible
- Future proof
  - Easy to adopt to tougher standards
  - Harvest bioplastics
Biopolymer in granules

- Granules contain 15-25% of structural gel, mainly alginate like polysaccharides
- Easy to harvest
- High market value
- Preparing development project to recover biopolymer and upgrade into non-food applications
International Award Winning Innovation

- Ingenuity award 2005
- Process Innovation award 2006
- DOW energy award 2007
- Water Quality & Safety award 2007
- Simon Stevin Gezel Award 2007
- Runnerup European Business Award for Environment 2008
- Technical Excellence Award SAICE 2009
- Energy Globe 2010 (National Winner)
- Runner up European Inventor Award 2012
- Simon Stevin Meester Award 2013
- Water Innovation Prize 2013

Lee Kuan Yew Water Prize 2012
Prof. Van Loosdrecht TU Delft
Nereda® is ....

- cost-effective in construction and operation
- compact
- sustainable & robust
- extensive simultaneous biological organic, N and P-removal in one process step
- suitable for retrofits and greenfields
- produces effluent quality that is future-proof

a modern technology ready for serious and sustainable action.

- tank sizes meeting world largest SBR’s
- existing international applications demonstrate advantages
- will become the new standard
More information

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