





Andreas.Giesen@rhdhv.com




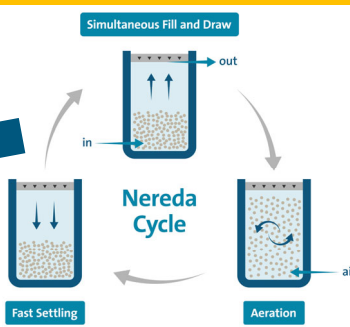
Aerob korrelslib: van nul naar honderd en snel duurzaam verder.



Hét Nationale Watersymposium

WASTEWATER TREATMENT WITH NEREDA®

- Natural and cost-effective way of purify wastewater

<p>NEREDA GRANULES 8 g/l or more $SVI_{5} \approx SVI_{30}$</p> <p>Small footprint</p> <p>30-50% energy saving</p> <p>Lower CAPEX</p> <p>Lower OPEX</p> <p>Robust & Resilience</p> <p>Biopolymer recovery</p>		<p>FLOCS 4 g/l $SVI_{5} > SVI_{30}$</p>  <p>Nereda Cycle</p>
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Nereda® a product of Royal HaskoningDHV

VAN NUL TOT HONDERD

- Uitgevonden en geïmplementeerd door TU Delft
- RHDHV geïnteresseerd voor industrieel afvalwater?
- Zagen groot potentieel voor stedelijk afvalwater en projectvoorstel bij STOWA ingediend:
 - haalbaarheidsstudies
 - eerste proefonderzoek op rwzi Ede
- RHDHV verwerft de octrooien
- Publiek-Private Samenwerking: Nationaal Nereda Onderzoeksprogramma



■ Prof Mark van Loosdrecht

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Nereda[®] | Royal HaskoningDHV

KRITISCHE SUCCESFACTOREN (1)



- TU Delft
 - Prof. Mark van Loosdrecht
 - Prof. Merle de Kreuk
- STOWA en betrokken waterschappen
- De 1^{ste} pilot (Ede)
- De 1^{ste} industriële full-scale (Vika, Ede)
- Het NNOP

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Nereda[®] | Royal HaskoningDHV

KRITISCHE SUCCESFACTOREN (1)



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/A en betrokken waterschappen

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- Het NNOP

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Nereda[®] partner Royal HaskoningDHV

KRITISCHE SUCCESFACTOREN (2)



- Pilots Aalsmeer, Hoensbroek, Dinxperlo en Epe

- Meer industriële toepassingen

- Opschaling demonstraties

- STP Gansbaai, Zuid-Afrika
 - 63.000 IE met SBR als "fall-back"
 - Nog steeds in bedrijf
- STP Frielas, Lisabon, Portugal
 - 700.000 IE zuivering met 5 straten
 - demo in 25% van 1 straat
 - Later omgebouwd tot 2 full-scale reactoren

- rwzi Epe: 1^{ste} huishoudelijke Nereda in NL

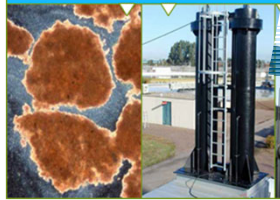
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Nereda[®] partner Royal HaskoningDHV

KRITISCHE SUCCESFACTOREN (2)

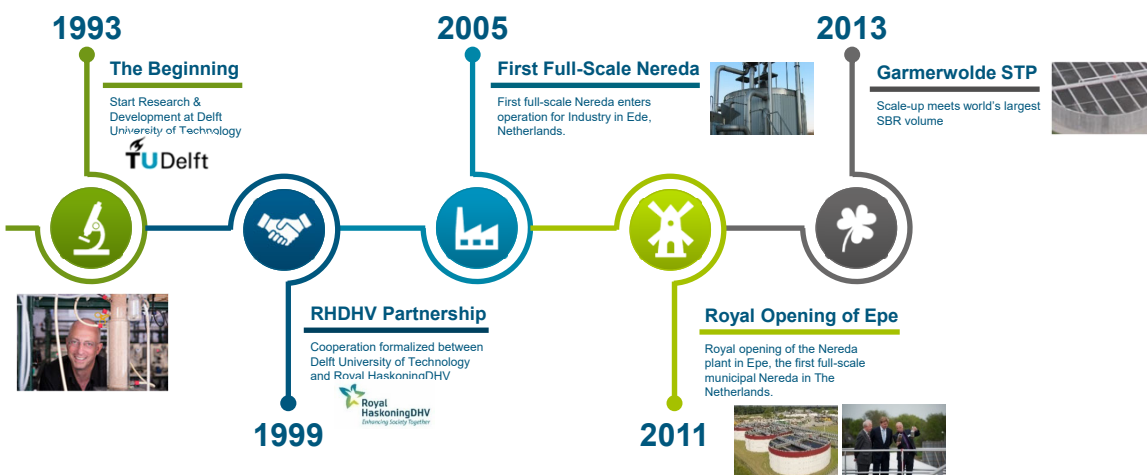


1993 2002 2003 2004



- Pilots Aalsmeer, Hoensbroek, Dinxperlo en Epe
- Industriële toepassingen
- Scaling demonstrations
- STP Gansbaai, Zuid-Afrika
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HISTORY AND DEVELOPMENT





HISTORY AND DEVELOPMENT

1993

The Beginning

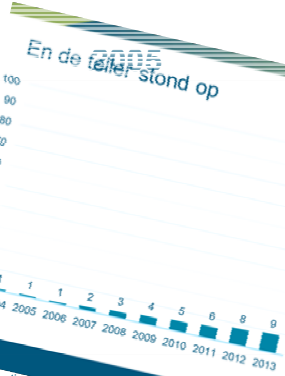
Start Research & Development at Delft University of Technology



1999



Cooperation formalized between Delft University of Technology and Royal HaskoningDHV



2013

Garmerwolde STP

Scale-up meets world's largest SBR volume



2011



HISTORY AND DEVELOPMENT

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The Beginning

Start Research & Development at Delft University of Technology



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RHDHV Partnership

Cooperation formalized between Delft University of Technology and Royal HaskoningDHV



2005

First Full-Scale Nereda

First full-scale Nereda enters operation for Industry in Ede, Netherlands.



2013

Garmerwolde STP

Scale-up meets world's largest SBR volume



2011



Royal Opening of Epe

Royal opening of the Nereda plant in Epe, the first full-scale municipal Nereda in The Netherlands.



2020



Global Technology

GWJ names Nereda "Breakthrough Technology of the Decade"



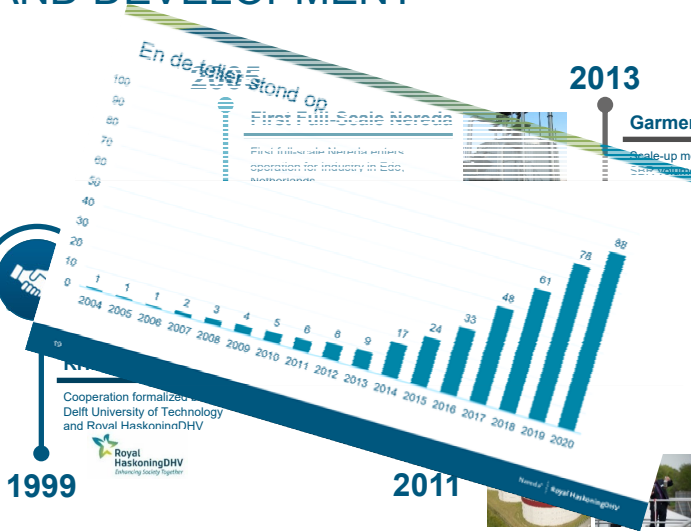


HISTORY AND DEVELOPMENT

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Start Research & Development at Delft University of Technology
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2020

Water tech's best and worst of the decade

Rank	Technology	Reason
1	Nereda	Best
2	Water reuse	Best
3	Water reuse	Worst

KRITISCHE SUCCESFACTOREN (3)



- Focus op grootschalige stedelijke zuiveringen en opbouw indrukwekkende referentielijst
- Focus op best werkende referenties
 - Nereda Controller
 - Data analytics & dashboarding
 - Remote support
 - Dialoog met operators
- Onze bedrijfscultuur
- Internationaal netwerk en partners



KRITISCHE SUCCESFACTOREN (3)



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Nereda[®] | Royal HaskoningDHV

NEREDA[®] GLOBAL PRESENCE



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Royal HaskoningDHV

VAN NUL TOT HONDERD EN SNEL DUURZAAM VERDER

MARKET DRIVERS: DO MORE WITH LESS



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Nereda[®] | Royal HaskoningDHV

Verdygo adopted by more and more Dutch Water Authorities

- Standardized modular treatment plant units
- Designed for sustainable construction, material reuse & flexible future adjustment
- Modular and mobile pre-fabricated units (container or skids)
- Built above ground and connected by plug&play
- Nereda as one of the biological treatment standard



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All biological wastewater treatment technologies emits some N2O

- N2O has a global warming potential that is 265 times higher than CO2.
- Large variability in reported N2O emission for classical wastewater treatment technologies
 - between different wastewater treatment systems AND within different types of wastewater treatment systems AND during different seasons/flow variations
 - Emission factor in range of 0.x to >10% kg N2O per kg TN influent (Foley et al 2011)
- Extensive monitoring at Nereda Dinxperlo showed at least similar or better emission factor

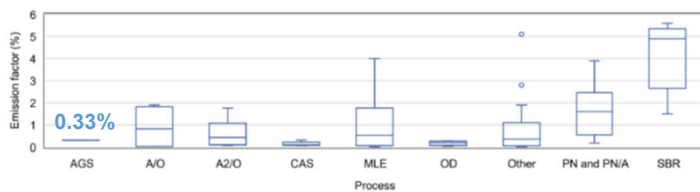


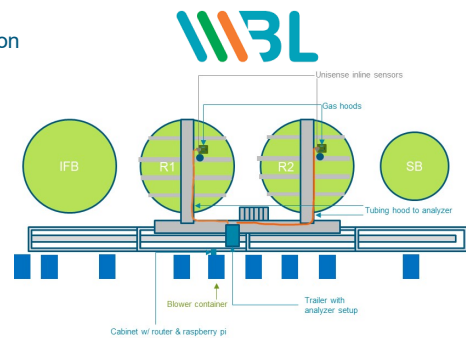
Fig. 15. Emission factor of nitrous oxide for different wastewater treatment systems, adapted from (Vasiliki et al., 2019). Process groups: AGS: Aerobic Granular Sludge, A/O: Anoxic/oxic reactor, A²/O: anaerobic-anoxic-oxic reactor, CAS: conventional activated sludge, MLE: Modified Ludzack-Ettinger reactor, OD: oxidation ditch, SBR: sequencing batch reactor, PN and PNA: partial-nitrification and partial-nitrification-anammox process.



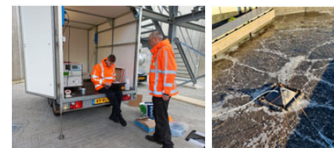
Water Research
 Available online 24 April 2023
 Nitrous oxide emission from full-scale municipal aerobic granular sludge
 Edward J. van Dijk, ...
 Add to favorites, Share, Print

Application research Nereda Panheel

- Purpose: develop active control strategies to further minimize N2O emission
- Set-up:
 - 1 reference reactor and 1 "test" reactor
 - Trial various control strategies and monitor emission
- Preliminary results:
 - Emission factor reference similar to Dinxperlo
 - Adjustment of control strategies can indeed lead to reduced emission
 - E.g. effect of increased DO trial (in April 2023)
 - DWF: 2 mg/l → 4 mg/l / RWF: 3 mg/l → 6 mg/l



- To be continued



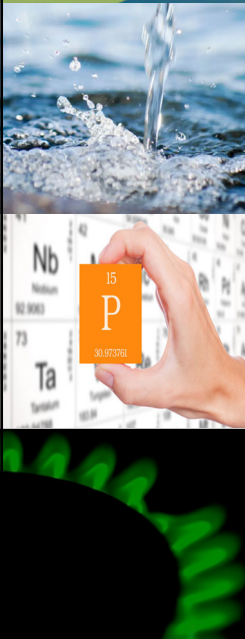


Micropollutant removal

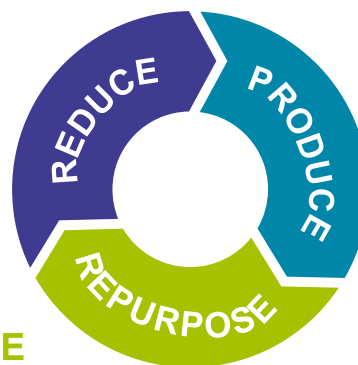
- Validated effectiveness of powder activated carbon dosing into Nereda
- Effective micropollutant removal and tuneable by dosing rate
- No negative effect on biological treatment performance and granulation
- Will be integrated in upcoming Nereda Controller updates



FROM WASTE TO RESOURCE



REDUCE



PRODUCE

REPURPOSE



FROM WASTE TO RESOURCE







REDUCE

Nereda granules are 15 – 20% Kaumera. Extracting this portion reduces sludge treatment and disposal cost.

PRODUCE

Kaumera extraction produces a valuable biopolymer from the Nereda sludge.

REPURPOSE

Kaumera is a valuable raw material with promising applications for generating additional revenue.

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Kaumera Extraction Installation



Waterschap  Rijn en IJssel

WATERBEHEER: VEILIG EN OP MAAT



waterschap
vallei en veluwe



2019 Zutphen: first Kaumera Extraction Installation on **dairy** (only industrial) wastewater treated in Nereda.
Processing 2,800 ton DS/year of sludge



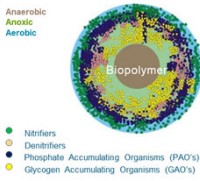
2020 Epe: first Kaumera Extraction Installation on **municipal** wastewater treated in Nereda.
Processing 250 ton DS/year of sludge

Nereda® by Royal HaskoningDHV

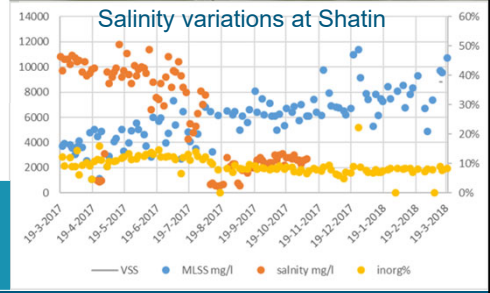
HIGHLY RESILIENT

- Granulation intrinsically embedded in simple 3 step cycle
- Continuous suppression of filamentous growth
- Biopolymer provides resilient during less favorable conditions:
 - Salt fluctuations
 - Chemical spikes
 - pH fluctuations
 - Temperature fluctuations
 - Load variations
- Highly relevant to industrial applications

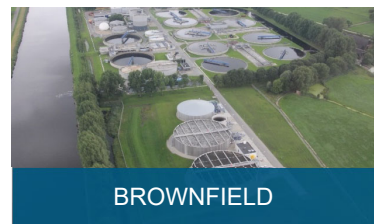
Shock addition of 5,000 ppm NaCl: activated sludge vs. AGS after 5 min settling



Sudden start/stop of sea water toilet flushing caused no noticeable effect



NEREDA[®] CONFIGURATIONS



Nereda Hybrid: unlocking synergetic potential

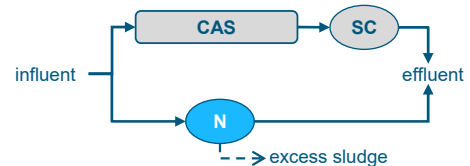
Principle

- Nereda® in parallel to Conventional Activated Sludge (flow-through or SBR)
- Waste good settling excess sludge to CAS

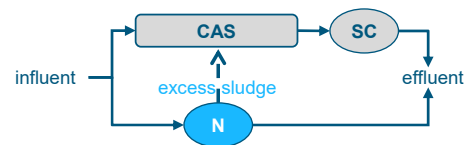
Advantages include

- Easier integration & operation existing sludge processing
- Supporting & Augmenting performance existing CAS
 - improved SVI (densification)
 - higher sludge concentrations
 - continuous inoculation with nitrifying / bio-P sludge
 - Increased process resilience

PARALLEL EXTENSION



HYBRID EXTENSION



Nereda Hybrid: unlocking synergetic potential

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Vroomshoop Hybrid with Flow-Through



Ringsend Hybrid with SBR



NEREDA® RINGSEND

Ireland

Client:
Uisce Éireann (Irish Water)

Capacity:
625,000 m3/day | 2,400,000 PE

2,000,000 PE Retrofit

- 8 Upper Deck SBRs → Nereda®
- 4 Upper Deck SBRs → Hybrid Nereda®
- 12 Lower Deck SBRs → Hybrid Nereda®

400,000 PE Capacity Upgrade

- 6 new Nereda®

Digestion Upgrade

- Retrofit to Ephyra®

Nereda® in partnership with Royal HaskoningDHV

HARKOS (HarnAschpolderRKOrrelSlib)

2015: Future challenges for existing WWTPs using activated sludge:

- Water reuse
- Capacity / effluent quality
- Resource recovery
- Energy

Harnaschpolder WWTP
• Capacity : 1.26 million p.e.

Get ready for the future within existing space?

TU Delft

DEFLUENT Services bv

Hoogheemraadschap van Delfland

Hoogheemraadschap van Rijnland

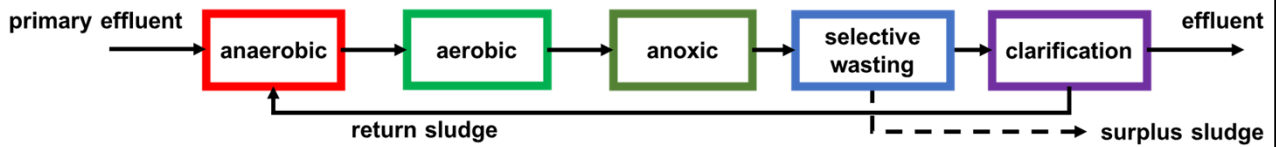
vides industriewater

Royal HaskoningDHV Enabling Society Together

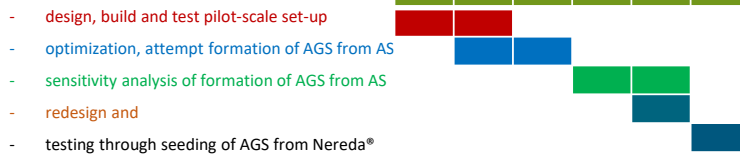
Nereda® in partnership with Royal HaskoningDHV

Research and timeline Harkos

- Key research question:
 - How to translate the selective pressures for granule formation from Nereda®?
 - How large are the benefits for retrofit of CAS-systems, at what cost?



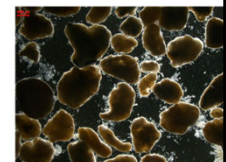
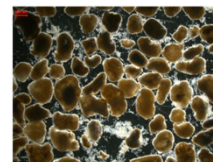
Timeline of pilot-scale research:



Nereda® Royal HaskoningDHV

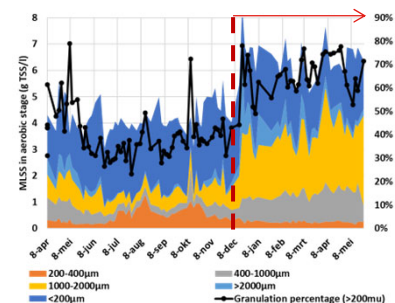
Current status

- Able to retain granules and grow more
- Similar granules as in Nereda SBRs
- Average SVI_{30} of approx. 50 ml/g
- Average MLSS of approx. 6.5 g/l
- Average granulation (> 0.2 mm) percentage approx. 70%
- Doubled volumetric capacity



→ Proof-of-principle

→ Next step: validation in scale-up pilot at full-scale





VAN 0 NAAR 100
in ca. 18 jaar

 Celebrating 100 Nereda Projects

moderne standaard die 100 jaar oude actiefslib vervangt

EN SNEL DUURZAAM VERDER

Voorbeelden tonen hoe technologie verder evolueert en oplossingen biedt ook voor uitdagingen van morgen

en vast nog 100 jaar blijft bijdragen aan duurzame waterzuivering

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