AEROBIC GRANULAR SLUDGE "NEREDA®" TECHNOLOGY APPLICATIONS

Monita Naicker [1], Rosalie Rosnik [2], Arnold Zilverentant [2]
1. Aquatec Maxcon, Brisbane, Queensland, Australia
2. Royal HaskoningDHV, Amersfoort, the Netherlands

ABSTRACT

Aerobic granular sludge technology, "Nereda®" is maturing as an alternative application to activated sludge processes. There are now several plants in operation worldwide applying Nereda® technology successfully for various industrial and municipal applications.

This paper provides a brief overview of the performance of these plants and how Nereda® technology can be applied to meet the demands for water authorities in Australia with population growth, improving effluent quality and reducing energy footprint.

INTRODUCTION

Aerobic granular sludge technology, "Nereda®" is maturing as an alternative application to activated sludge processes. Aerobic granules were defined at the First Aerobic Granule Workshop 2004, Munich, Germany which stated "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." Nereda® technology uses control measures to ensure that the environment within the bioreactor is favourable for the natural selection processes to encourage formation of granular structure. The granules formed allow simultaneous anaerobic, aerobic and anoxic conditions to exist within its structure and hence, reduces the need for multiple compartments and recycles within the bioreactors.

The research and development of aerobic granules commenced at Delft University in 1993. In 2002, aerobic granular sludge was discovered and stable laboratory scale granulation was achieved. This was followed by pilot scale research with several pilot plants having been in operation for both industrial and municipal influent since 2003. In 2005, the first industrial full scale Nereda® prototype was retrofitted into an existing tank. This was followed by full scale municipal and industrial plant applications. The first full scale Nereda® Plant was built in 2010 at Epe, the Netherlands and has been in operation for the last three years. In the meantime, several plants are in operation worldwide applying Nereda® technology successfully to various industrial and municipal applications. This paper provides a brief overview of the performance of these plants and how Nereda® technology can be applied to meet the demands for water authorities in Australia with population growth, improving effluent quality and reducing energy footprint.

METHODOLOGY/ PROCESS

A number of Nereda® plants that have been in operation include the following:

1. Gaansbai STP is a 63,000EP demonstration plant in South Africa that was built as retrofit to the SBR Solution. This has been in operation since 2010.
2. Epe STP - 59,000EP full scale plant in the Netherlands, which has been operational for three years and is meeting TN requirements of <5mg/L and TP of <0.3mg/L.
3. Frielas (1MLD) Demonstration Plant – a portion of the existing 250,000EP activated sludge plant was converted to Nereda® to compare performance, reliability and energy consumption between the processes.
4. Garmerwolde STP Upgrade - 140,000EP Nereda® Plant to increase the capacity of the existing (235,000EP) A/B SHARON sewage treatment plant.
5. Vroomshoop Hybrid Solution – a 25,000EP demonstration plant to inoculate Nereda® granular sludge to a conventional activated sludge process to improve plant performance. The plant was commissioned in 2014.
6. Dinxperlo STP – a 16,000EP Nereda® plant that is integrated into the public water park. The plant was commissioned in 2014.

RESULTS/ OUTCOMES

Gaansbai STP, South Africa

The Gaansbai Plant was built as sequence batch reactors. It was fitted out as a Nereda® reactor with only a single tank required to meet the plant load. The results from the performance trial met all the effluent quality requriements despite receiving large volumes of septic sewage. Refer to Table 1 for a summary of the results.

Epe STP, the Netherlands

The Epe STP results have been previously discussed at Ozwater 13. The energy consumption at Epe STP after three years of operation has been maintained at 21.2kWh/EP (based on 150g COD per person).

Frielas STP, Portugal

At the Frielas Plant, since Nereda® reactor is operated in parallel with the conventional aeration tanks using the same water depth, existing and common air supply equipment, etc., energy consumption comparison drawn between Nereda® process and conventional process is reliable and representative.

During a two month monitoring period, the air consumption was measured with the dissolved oxygen (DO) levels similar with nitrification in Nereda® Tank fully suppressed to mimic the biological performance of the activated sludge reactors. The measured air flow consumed in each system per mass of chemical oxygen demand (COD) removed was translated into the specific electricity consumption. The average specific consumption for the Nereda® amounts to 0.35 kWh/kg COD removed. This represents approximately 30% electricity savings for aeration, compared to the current activated sludge system.

Garmerwolde STP, the Netherlands

Since its 2005 retrofit into an AB/SHARON process, the Garmerwolde STP was not able to meet the required nutrient removal targets. Nereda® upgrade of Garmerwolde STP was selected as the lowest capital cost over 20 alternative processes.

The solution involved the addition of two 9,500 m^3 Nereda® reactors, with 150,000EP total capacity in parallel to the existing plant- this equates to 30,000 m^3/day average and 4,200m^3/h peak flow. The plant was commissioned in 2013 with seed sludge from the existing activated sludge plant. During the sludge transformation process, the treated flow was gradually increased and met the design flow within approx. 3 months. During start-up, nitrogen removal was almost instantaneous meeting the discharge, while extensive biological phosphate removal developed over the three month period.

Currently, the plant is in its one-year performance test period to validate that the combined effluent meets the target of TN <7 mg/L and TP<1 mg/L. The energy consumption of both the Nereda® as the AB-system is closely monitored.

Table 2 shows the early results from Gamerworlde STP comparing the results from both processes. With inherent P-removal, the Nereda® process stream has no requirements for additional metal dosing. It also indicates clearly that the Nereda® process is 50.1% more energy efficient than the AB/SHARON based on specific energy consumption rates.

Vroomshoop STP, the Netherlands

The sewage treatment plant at Vroomshoop consists of a Carrousel® reactor (2,400m^3) and Nereda® reactor(1350m^3) operating together to deliver TN – 10mg/L and TP – 2mg/L. Each reactor at ADWF treats 50% of the plant influent. Currently, the energy usage of both the combined plants is 22.9kWh/EP (based on 150g COD per person). It is expected that through additional process tuning that this will be reduced by an additional 15%.

Dinxperlo STP, the Netherlands

The capacity of Dinxperlo STP is 3,100m^3/day with peak flows up to 570m^3/h. The process flowsheet is similar to Epe STP with three Nereda® tanks and tertiary filteration.

Currently, the specific energy consumption for operating the plant is 27.1kWh/EP (based on 150g COD per person). Compared to typical specific energy consumption of 55kWh/EP from conventional plants of similar size (10,000-20,00EP) in Australia, the energy consumption of Dinxperlo is 49% more energy efficient.

Other Nereda® Installations

The reference list for Nereda Projects is shown in Table 3 with the world wide installations exceeding 15 Plants, including 12,500EP first Australian Nereda® Plant in Kingaroy, Queensland.

Several pilot plants are in operation worldwide to assess the viability of Nereda® for large (>500,000EP) applications and are showing promising results. The decision for client's to adopt Nereda® technogy is ranging from meeting stringent energy requirements, capital savings from smaller structures and/or availabilty of real estate and retrofitting into existing structures.

CONCLUSION

The applications of Nereda® technology are expanding as a means of future proofing existing assets by implementing either a retrofit solution (Frielas STP, Gaansbai STP), a parallel process upgrade (Garmerwolde STP) or a hybrid solution, which is currently under trial at Vroomshoop.

Over past twenty years, the Nereda® aerobic granular biomass technology has been developed from laboratory, pilot and prototype into large scale applications.

As demonstrated from the current operating plants, Nereda® technology offers significant benefits through simplified operation, and reduced capital and operating costs. For water authorities, it provides a unique opportunity to implement low cost process upgrades that could delay or eliminate the need for large scale capital investment.

ACKNOWLEDGMENT

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Table 1 shows the results from Gaansbai Demonstration Plant performance data.

Table 1: Gaansbai STP Performance Data (2011)

Parameter	**Influent** (mg/L)	**Effluent** (mg/L)	**Requirement** (mg/L)
COD_{total}	1265	40	75
TKN	115		
NH_4-N	75	<1	6
TN		<10	15
TP	19	3.2	10
SS	450	<5	

Figure 1 shows the conversion of one of the reactors of Frielas WWTP to Nereda® technology.

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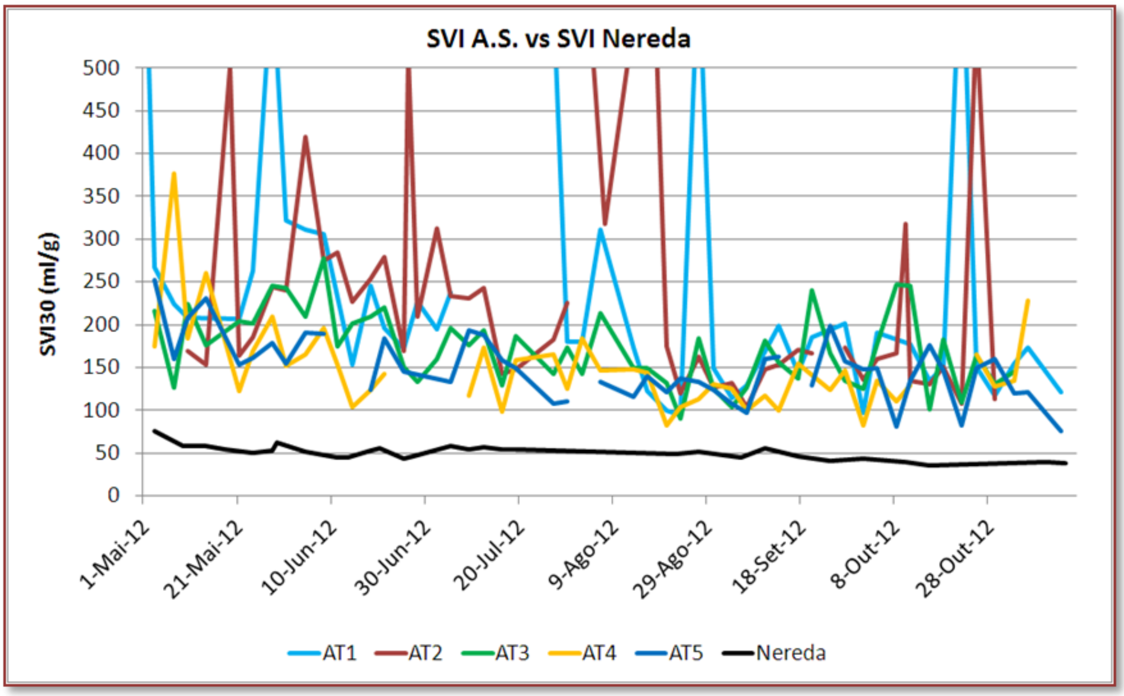

Figure 2 – Comparison between the settleability of the biomasses from the Nereda® reactor and the activated sludge (AS) from the other five biological reactors (AT) in the Frielas WWTP

Figure 3 illustrates the specific energy savings of Nereda® compared with the existing conventional activated sludge at Frielas STP, Portugal.

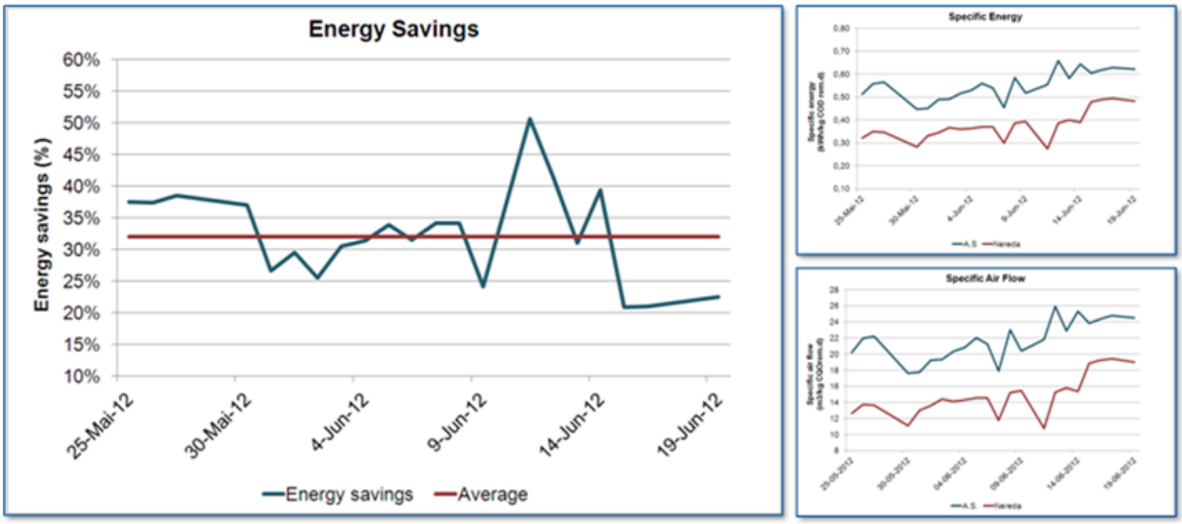

Figure 3: Frielas STP – Energy Comparison between existing Activated Sludge Plant and Nereda®

Figure 4 shows the Nereda® upgrade (140,000EP) at Garmerwolde STP, constructed alongside the existing A/B SHARON Plant (235,000EP).

Figure 4: Garmerwolde STP – 140,000EP

Table 2: Garmerwolde STP Performance Data

Parameter		AB System	Nereda	Remarks
Flow	m^3	2,902,000	1,743,000	7 weeks' time
Load	P.E.-150	178,000	107,000	
Energy	kWh	692,000	211,000	AB incl. Sharon
Sludge	kg	618,000	221,000	
PAC	kg	28,600	0	Sludge properties
C-source	kg	54,000	0	Denitrification
Fe	kg	23,500		P-removal

Table 3: Nereda® References, Jan 2015

Plants	Capacity	Nereda ® Reactors
Municipal		
STP Epe (Netherlands)	36,000 m^3/day; 59,000 PE incl. 13,750 PE industrial discharges	3 x 4,500 m^3
STP Utrecht (Netherlands)	5,000 m^3/day; 530,000 PE (demo contracted)	1 x 1,000 m^3
STP Garmerwolde (Netherlands)	100,000 m^3/day; 140,000 PE	2 x 9,500 m^3
STP Vroomshoop (Netherlands)	30,000 m^3/day; 25,000 PE	1 x 2,400 m^3
STP Dinxperlo (Netherlands)	13,700 m^3/day; 15,730 PE	3 x 1,250 m^3
STP Lisbon (Portugal)	3,000 m^3/day; 10,000 PE (semi full-scale retrofit demo)	1 x 1,000 m^3
STP Gansbaai (South Africa)	5,000 m^3/day; 63,000 PE	3 x 1,600 m^3
STP Stellenbosch (South Africa)	5,000 m^3/day; 40,000 PE	2 x 1,800 m^3
STP Ryki (Poland)	5,300 m^3/day	2 x 2,500 m^3
STP Limeira, Tatu (Brazil)	57,024 m^3/day; 517,000 PE	3 x 6,500 m^3
STP Rio de Janeiro, Deodoro (Brazil)	86,400 m^3/day; 480,000 PE	3 x 6,300 m^3
STP Rio Claro, Jardim Novo (Brazil)	23.500 m^3/day; 133.000 PE	3 x 3,500 m^3
WWTP Kingaroy, Qld, (Australia)	2,625m3/day; 12,500PE	2 x 1300 m^3
Industrial		
Vika, Ede (Netherlands)	50-250 m^3/day	1 x 100m^3
Cargill, Rotterdam (Netherlands)	700 m^3/day	2 x 1,600 m^3
Smilde, Oosterwolde (Netherlands)	500 m^3/day	1 x 300 m^3