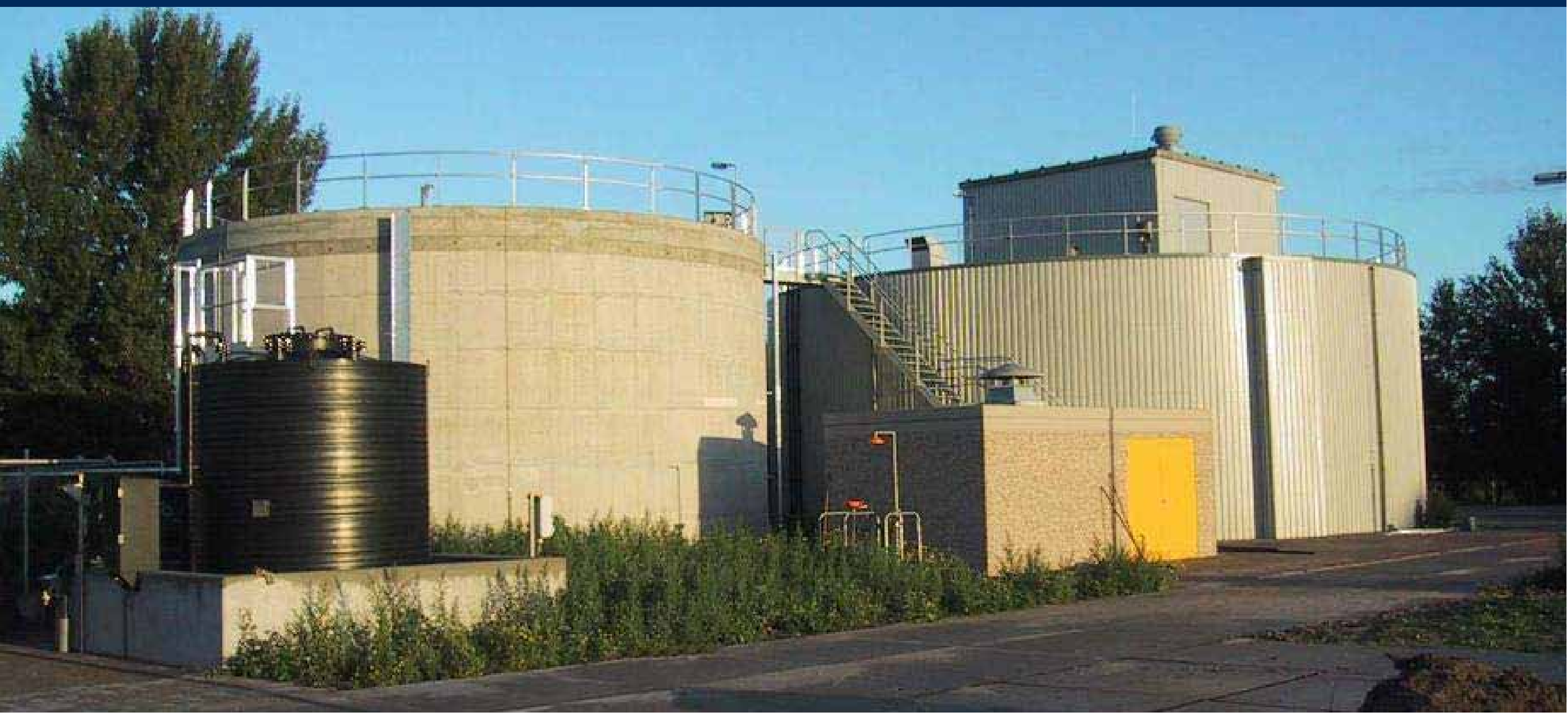
SHARON

N-Removal Over Nitrite



Grontmij

www.grontmij.co.uk

Contents

1 Introduction

SHARON is a very cost-effective treatment system for the total removal of nitrogen components from wastewater flow streams through nitrification/denitrification. The system is used for the treatment of municipal wastewater side streams from both dewatered digested primary sludge and waste activated biosolids to achieve high overall nitrogen removal. In addition it can be used to treat wastewater flows from sludge dryers and incinerators.

SHARON is a high rate process for the removal of total nitrogen operating with minimal sludge retention time. Due to differences in growth rates of the bacterial species at the process design temperature (30-40°C), a selection can be made wherein the nitrite oxidizing bacteria can be washed out of the system while ammonia oxidizing bacteria are retained along with denitrifying bacteria.

Using this metabolic mode of operation allows for a 25% reduction in aeration energy required for nitrification and a 40% reduction in the amount of Biological Oxygen Demand (BOD) needed for denitrification. In addition, since the process is accomplished in a side stream there are savings in mainstream reactor costs.

The process has moved beyond the development stage. Four full-scale SHARON systems have been constructed at large wastewater treatment plants in Rotterdam, Utrecht, Zwolle and Beverwijk (all in the Netherlands). SHARON plants are currently in the design phase for Groningen (the Netherlands) and New York City (USA). The Utrecht plant has been in operation since 1997 whilst the Rotterdam, Dokhaven plant was completed in 1999. The Zwolle plant and Beverwijk plant were commissioned in 2003. The pertinent data for the start-up and continuing operation of the Utrecht and Rotterdam plants are presented and discussed below.

The SHARON process has also been successfully tested on wastewater from the dewatering and drying of digestate from a combined manure and organic slurry digestion plant (MAV, Ghent, Belgium). This 50 m^3/h wastewater flow contains high levels of ammonia and suspended solids. It was determined that the SHARON process was preferable to treatment through conventional aerobic processes, a membrane bioreactor, or non-biological methods such as ammonia stripping.

Compared to these other processes, the SHARON process configuration was found to be technologically less complex and more flexible. Moreover the investment and operational costs are considerably lower.

General comparison of different techniques for N-removal from rejection water

	Production chemical sludge	Production biological sludge	Dosage chemicals	Energy requirements	Operation	Cost* estimate Euro/kg N
Air stripping	yes	no	yes	average	average	6.0
Steam stripping	yes	no	yes	high	complex	8.0
MAP/CAFR process	yes	no	yes	low	complex	6.0
Membrane bioreactor	no	yes	yes	high	average	2.8
Biofilm airlift reactor	no	low	yes	average	average	5.7
SHARON process	no	low	yes	average	average	1.5

*Cost estimate based on STOWA[1] (1996) for WWTP capacity of 500.000 p.e.

1 The STOWA (Dutch acronym for the Foundation for Applied Water Research) coordinates and commissions research on behalfof a large number of local water administrations. Among the 61 bodies which contribute to the STOWA, there are water boards, provinces and the Ministry of Transport, Public Works and Water Management

2 SHARON N-Removal Over Nitrite

Compact systems for treatment of concentrated wastewater flows are increasingly more important, particularly where space is lacking. A new development is the SHARON (Single reactor system for High activity Ammonia Removal Over Nitrite). SHARON is a joint development of Grontmij, TU Delft and the Waterboard ZHEW. SHARON is especially fit for treatment of nitrogen rich filtrate from sludge digestion, the treatment of landfill leachate and the treatment of various concentrated industrial

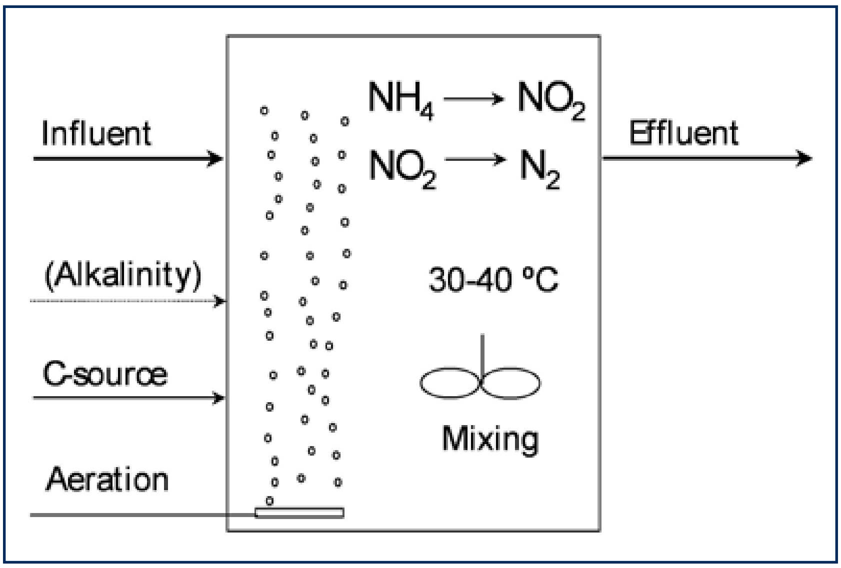
Background

Bacterial activity increases at high temperatures. At temperatures of 30 - 40°C nitrifying sludge needs only a short residence time. At these high temperatures nitrogen-rich waste-waters can be treated in a single reactor. No sludge retention is required to maintain the nitrifying sludge in the system as long as thehydraulic retention time is equal or higher than the minimum sludge retention time. SHARON (pat.) is specially fit for treatment of nitrogen-rich wastewaters, for example rejection water from the dewatering of digested sludge at a WWTP. Furthermore SHARON is also fit for pre-treatment of various highly concentrated industrial wastewaters.

Advantages

Compared to other techniques for treatment of nitrogen-rich wastewaters like steam stripping, the MAP-process or the air lift reactor, SHARON has several advantages:

- low investment costs
- low operational costs
- no chemical by-products
- simple operation and maintenance
- easy start-up
- insensitive to high influent SS levels
- negligible odour emission

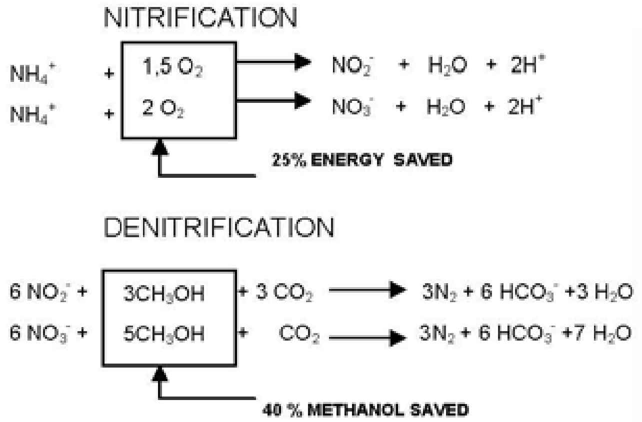


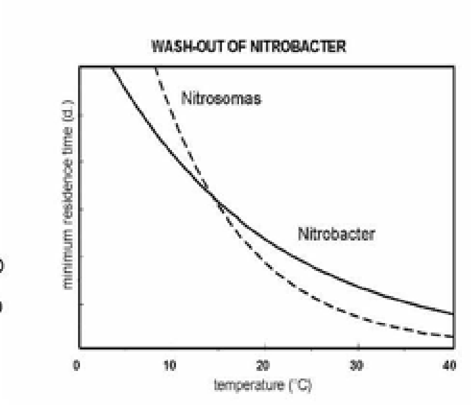
Schematic representation of SHARON

2 SHARON N-Removal Over Nitrite

Results of rejection water treatment SHARON Rotterdam

parameter	dimension	value
Nkj influent	mg/l	1.000 - 1.500
N-removal	%	> 95
HRToxic	day	1,0 - 1,5
temperature	°C	30 - 40
pH	-	7,0 - 7,5
oxygen	ppm	1,0 - 1,5





In conventional aerobic systems the biological ammonia oxidation comprises of two steps.
First the oxidation of ammonia to nitrite by Nitrosomonas and subsequently the oxidation of nitrite to nitrate by Nitrobacter.
At higher temperatures Nitrosomonas prove to have significantly higher maximum growth rates than Nitrobacter.

So in a system without sludge retention they can survive at shorter residence times.
In a reactor with a temperature of 30 to 40° C and a short residence time mainly ammonia oxidation to nitrite occurs because Nitrobacter is washed out of the system.

PROCESS FEATURES

- no sludge retention
- simple process
- nitrite route reduces up to:
  - 25% oxygen demand
  - 40% methanol requirement
  - 40% sludge production
- maximum usage of alkaline buffer

APPLICATION

- rejection water of sludge digestion
- leachate water of landfill site
- waste water of composting process
- condensate of sludge drying

FULL SCALE PLANTS

- location: WWTP Utrecht (NL)
  capacity: 400.000 pe
  influent: rejection water
  N-load: 900 kg N_{kj}/d
  operational: 1997
- location: WWTP Rotterdam (NL)
  capacity: 470.000 pe
  influent: rejection water
  load: 850 kg N_{kj}/d
  operational: 1999
- location: WWTP Zwolle (NL)
  capacity: 200.000 pe
  influent: rejection water
  N-load: 410 kg N_{kj}/d
  operational: 2003
- location: WWTP Beverwijk (NL)
  capacity 320.000 pe
  influent: rejection water and condensate sludge drying
  N-load: 1.200 kg N_{kj}/d
  operational: 2003

3 Operating experience in The Netherlands

Operating experience in The Netherlands with a high rate process for total nitrogen control SHARON at Rotterdam and Utrecht

Introduction

This paper presents the performance results of the start-up and continuing operations of the SHARON process at the Utrecht and Rotterdam, Dokhaven Waste Water Treatment Plants (WWTP) in the Netherlands. The concepts for the SHARON process were initially developed by Delft University of Technology, Water Board ZHEW, and Grontmij. These concepts were pilot tested at Utrecht and Rotterdam before being implemented at full scale. The full-scale operations illustrate that the claims of the SHARON process have been successfully achieved.

The SHARON process

The SHARON process is a new and innovative process for total nitrogen removal which allows fornitrification/denitrification at minimal Solids Retention Time (SRT) values, resulting in a substantially smaller reactor volume than is currently required for conventional total nitrogen removal.

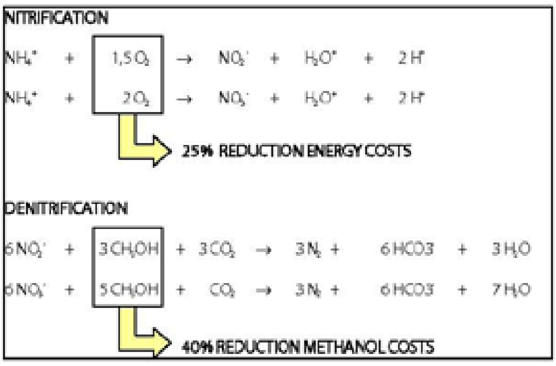


Figure 1 Biochemistry

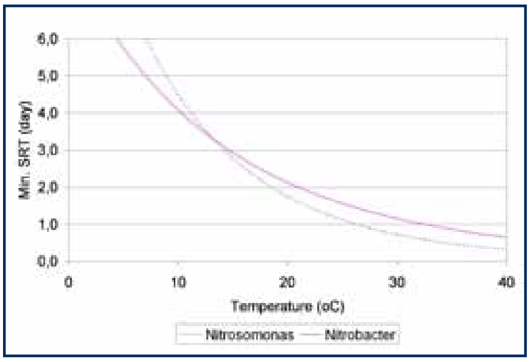


Figure 2 Growth rates

In addition the process allows for both a savings of twenty five percent (25%) in oxygen transfer energy and forty percent (40%) in carbon feed for denitrifying bacterial growth as compared to conventional processes because of the unique metabolic pathway used (Figure 1). The pathway is conversion of ammonia to nitrite and conversion of nitrite to nitrogen, the chemical species nitrate is not produced or converted.

The core concept on which the process is based is that at temperatures above 15°C, and especially between 30-40°C, the growth rates of the nitrifying bacteria are greater than the nitrafying bacteria. This allows for the design of a selector reactor whereby nitroso-genera bacteria (nitrifying) predominate over the nitro-genera bacteria (nitrafying (Figure 2). The nitrite produced is converted to nitrogen gas by denitrifying bacteria under anoxic conditions. This two step reaction can occur in either space or time (Figure 3).

SHARON at Utrecht

Design basis

The City of Utrecht is located in central Netherlands 25 miles Southeast of Amsterdam on the Amsterdam-Rijnkanaal. Utrecht is the fourth largest city in the Netherlands with a population of approximately 260,000. The city can trace its roots to Roman times.

The waste water works is a two step ammonia removal plant. Both the aeration tanks and intermediate sedimentation tanks are covered. The thickened biosolids are treated by anaerobic digestion and then dewatered in centrifuges. The recycled centrifuge decant is treated by the SHARON process. The SHARON process at this plant is a two-stage system with separate reactors for nitrification/nitrafication and denitrification/denitrafication (Figure 4).

3 Operating experience in The Netherlands

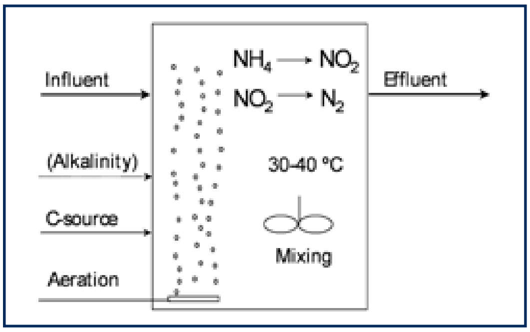


Figure 3 Reactor

Figure 4 Nitrification reactor (foreground), denitrification reactor (background)

The centrifuge's decant being recycled is pumped through a screening unit and into the first reactor, which is equipped with high efficiency jet-aerators (Korting) that provide both oxygen and mixing. The partially treated decant then flows to the second reactor, which is equipped with a mechanical mixer and recycled to the nitrification/nitrafication reactor.

The fully treated decant is then discharged to the head of the mainstream plant. A single building houses the Programme Logic Control (PLC) based system, a heat exchanger, and blowers to provide air to the jet aerators for oxygen transfer and mixing in the nitrification/nitrafication reactor. Methanol is contained in a buried storage tank and metered to the denitrification reactor. The design parameters for the plant are summarised in Table 1.

Parameter	
Flow design	**35.0 m³/hr**
Flow maximum	**62.5 m³/hr**
NH4 influent	**0.5-0.7 g/l**
Nitrogen Load design	**420 kg/day**
Nitrogen Load maximum	**900 kg/day**
Reactor Size	
oxic	**3,000 m³**
anoxic	**1,500 m³**
Oxic Retention Time	**2 days**
Anoxic Retention Time	**1 day**

Table 1 Design Parameters Utrecht,

Startup

The Utrecht plant was started up in September of 1997 [1]. The decant influent flow during the first 160 days was highly variable, as would be expected, ranging between 0 and 900 m^3/day. However the process rapidly attained stability and at twenty-one days after startup was attaining nitrification removal of 95% or more (Figure 5).

The startup was done using caustic soda to control pH in the reactors; at twenty-one days a switch was made to methanol. The methanol allowed denitrification/denitrafication to occur and consequently since alkalinity was recovered the caustic soda addition was stopped. The progress of denitrification/denitrafication can be observed by the falling nitrate and nitrite levels.

Nitrate concentrations fell from the 600mg/l level at twenty-one days to low levels by day eighty. The NOX-N level fell from over 600 mg/l to below 100 mg/l by increasing the inflow of methanol. Lower NOX-N levels are possible but not required to maintain a pH of approximately 7 in the reactor. The nitrate level remained under 200 mg/l and usually below 100 mg/l from eighty day point onwards to one hundred and sixty days. Nitrite concentrations fell from 600 mg/l at the thirtieth day to very low levels after the eightieth day and remained very low. This occurred with the influent ammonia varying between 450 and 700 mg/l during the period (Figure 6).

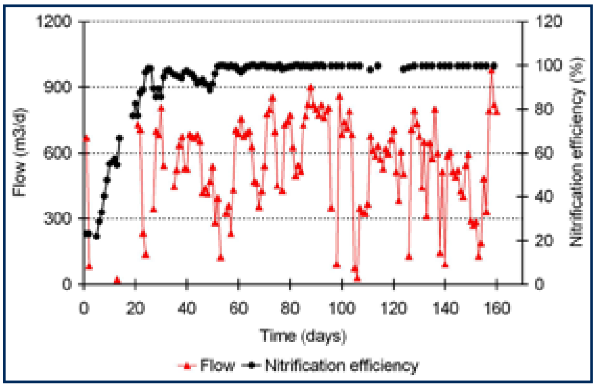


Figure 5 Start-up flow and removal efficiency

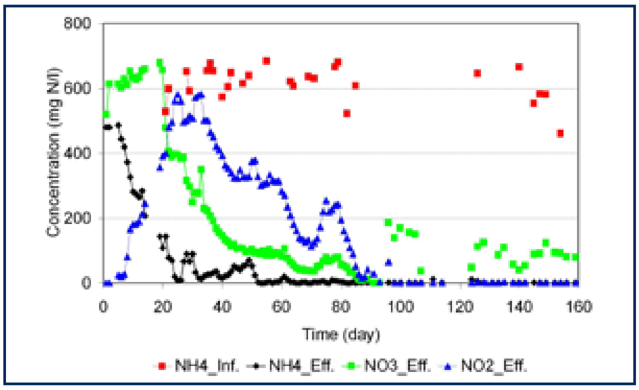


Figure 6 Start-up influent and effluent

3 Operating experience in The Netherlands

Continuing operation

A review of a full year's operating data for 1998 shows very stable operation [1]. The influent ammonia varied from 400 to 750 mg/l during the period with a highly variable flow ranging from 0 to 1,375 m^3/day (Figure 7). During this period the effluent ammonia averaged less than 5 mg/l, albeit with some peaks in the period from 50 to 100 days (Figure 8). The peaks were caused by insufficient pH control. The NOX-N concentration in the effluent was generally under 100mg/l (Figure 8).

The process was not upset by high influent suspended solids which at times reached concentrations of 30-50,000mg/l and were often above 10,000 mg/l (Figure 9).

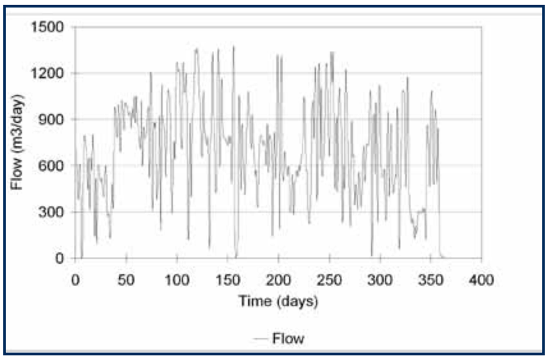


Figure 7 Continuous operation flow

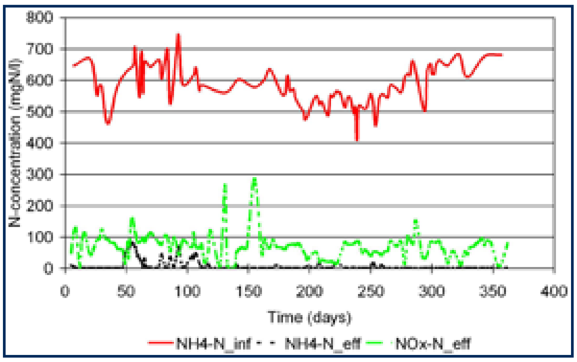


Figure 8 Continuous operation, influent and effluent

The control of pH was done through recovered alkalinity from denitrification/denitrafication caused by the addition of methanol in anoxic conditions. Occasionally supplemental sodium hydroxide, a backup pH control, is used in the case where insufficient methanol was dosed (Figure 10).

The influent temperature varied over the year between 20 and 30°C. The reactor temperature was raised to 38°C by means of biochemical heat production, there is no need to provide supplemental heat. The installed supplemental heat exchange unit operation has been discontinued as the required reactor temperatures are maintained through heat released by the reactions and the insulation of the reactors.

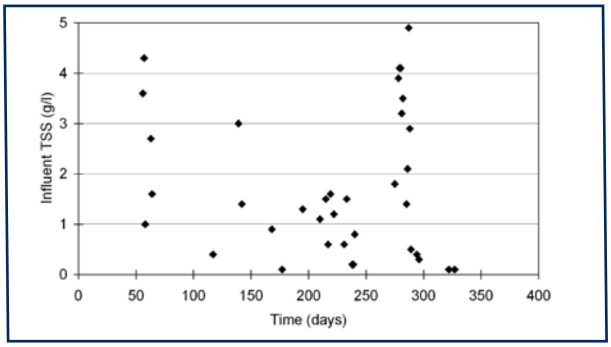


Figure 9 Continuous operation total suspended solids

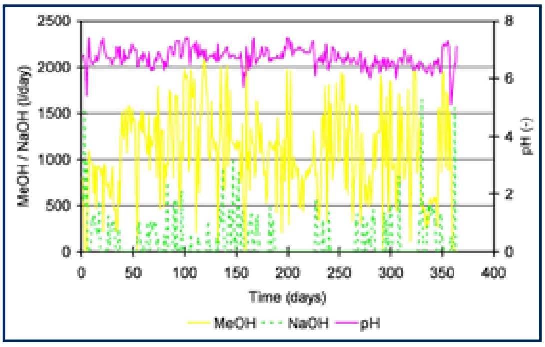


Figure 10 Continuous operation methanol and caustic soda dosing

It was the choice of the operations group to maximize ammonia removal so there was partial denitrafication via nitrate. The ammonia removal efficiency aimed for can only be achieved with an oxic retention time of more than 2 days and therefore the conversion is partially to nitrate and partially to nitrite. Thus there is only partial nitrogen removal via nitrite in this SHARON. This is confirmed by the average ratio of COD/ N-denitrafied which had a value of 3.3 g COD/ g N. In theory the minimal stoichiometric demand would amount to 2.86 g COD/g NO3-N denitrafied or 1.72 g COD/g NO2-N denitrified. Considering biomass yield, the demand is expected to be between 3.5 and 2.2 g COD/g N removed.

Since installation of the SHARON process the main stream plant has lowered the total nitrogen content in the effluent by 30%. During the first half of 1998 the total nitrogen content in the plant effluent dropped on average from 16 to 11 mg/l.

3 Operating experience in The Netherlands

SHARON at Rotterdam

Design basis

The city of Rotterdam is located in the Southwestern corner of the Netherlands on the banks of the River Meuse. Rotterdam is the second largest city in the Netherlands and the world's largest seaport. Its population is approximately 800,000. The city can trace its roots to medieval times. Its name, Rotterdam, comes from the dam built there in the 1200s in the river Rotte.

The waste water plant is a two step ammonia removal plant located in the old dock area on the south bank of the River Meuse. The aeration tanks, clarifiers, and administration building are installed in a filled in dock and are covered. The area has been landscaped and is covered with grass and serves as a park. The plant is surrounded by residential high rises (Figure 11).

The biosolids processing is done remote from the main stream plant but close by. The biosolids are thickened, anaerobically digested, and dewatered in centrifuges. The recycled centrifuge decant is pumped through in line screens to the SHARON reactor.

Figure 11 Rotterdam mainplant (background) and Biosolish (foreground)

Figure 12 Reactor left, methane storage background

Parameter	
Flow design	31.5 m^3/hr
Flow maximum	50.0 m^3/hr
NH4 influent	1-1.5 g/l
Nitrogen Load design	540 kg/day
Nitrogen Load maximum	830 kg/day
Reactor Size	
oxic/anoxic	1,800 m^3
Oxic Retention Time	1 day
Anoxic Retention Time	>0.5 days

Table 2 Design Parameters Rotterdam, The Netherlands [2]

The flow was initially heated in a spiral flow in line heat exchanger to the required reaction temperature. Since the initial period the reactor has been insulated and heat addition is no longer required. The design temperature is reached from the release of heat from biochemical reactions. The recycled centrifuge decant is treated by the SHARON process which was installed in an existing thickener (Figure 12).

The SHARON process at this plant is a one-stage system with a single reactor for nitrification and denitrification. That is the reactions are separated in time, one stage with sequencing steps. The centrifuges decant being recycled flows into the reactor which is equipped with high efficiency jet-aerators (Korting) that provide both oxygen transfer for the oxic phase where ammonia is converted to nitrite, nitrification, and mixing for the anoxic phase where nitrite is converted to nitrogen, denitrification.

In the oxic sequence step, nitrification, the surface is frothy from the turbulence created by the jet aerators. In the anoxic sequence step the air is turned off and the jets just pump liquid for mixing. The surface is broken only by rising nitrogen bubbles. The reactor is run with minimal mixed liquor solids. During the oxic phase the dissolved oxygen is held in the 1-2mg/l range; pH is held in the 6.8 to 7.2 range and monitored through out the reactor. The pH of the reactor is controlled, only, by methanol addition, which allows denitrification and consequent alkalinity regeneration. Supplemental caustic soda addition was installed as a backup pH control.

The trail gases are drawn through a piping manifold and exhausted. All process data outputs are sent to a PLC based computer, which monitors the operation and controls the sequencing of the oxic and anoxic steps. Automatic control is used for influent flow and chemical addition, oxygen, methanol, and caustic soda. The fully treated decant is then discharged back to the head of the mainstream plant. The design parameters for the plant were as follows:

3 Operating experience in The Netherlands

Start-up

The SHARON process was introduced at the Rotterdam Dokhaven plant in 1999 [2]. The SHARON reactor was filled with river water warmed to 30°C and seeded with waste activated sludge from the main stream treatment plant. The initial control of pH was by means of caustic soda addition.

Over the first seven weeks of operation, the nitrogen load to the SHARON reactor was increased until the entire production of centrifuge decant water was treated. The start up period lasted five months. Sludge dewatering in the decanters was dependent on sludge production and storage in the sludge buffer tanks. Therefore the flow during that period varied from zero to 980 m^3/day, the inlet ammonia concentration averaged 1,230 mg/l, with a maximum of 1,530 mg/l. This was 1.25 - 1.5 times the design basis.

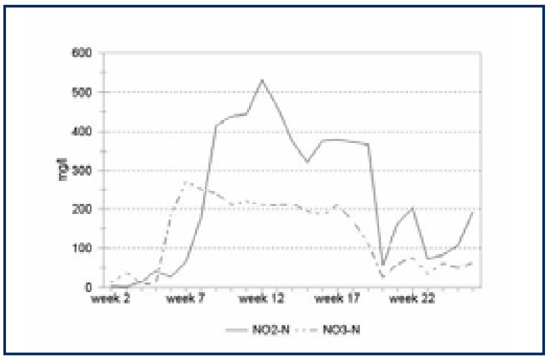


Figure 13 Start-up effluent NO2 and NO3

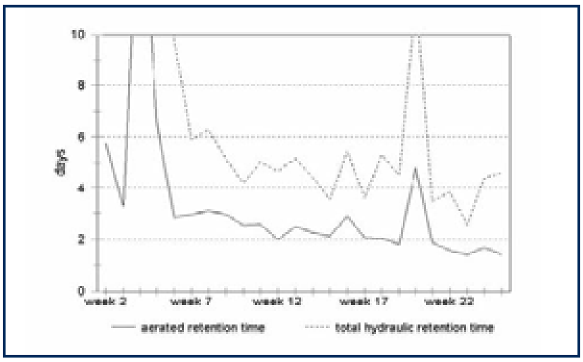


Figure 14 Start-up retention time

The start up period was longer than anticipated mainly due to dysfunction of pH and flow measurements. The ammonia in the influent was initially converted to both nitrate and nitrite due to oxic detention times higher than two days (Figure 13). Indeed oxic detention times ranged from 2-10 days in the startup period of week five to twenty (Figure 14). Methanol was dosed during the anoxic phase of the cycle.

Once the cycle times were properly controlled, the carbon / nitrogen ratio decreased to 2.4 indicating the metabolic path way utilized was principally via ammonia to nitrite to nitrogen (Figure 15). Once the process conditions were under control the total nitrogen removal efficiency steadily climbed. As the process stabilized the reactor temperature rose to its design point (Figure 16).

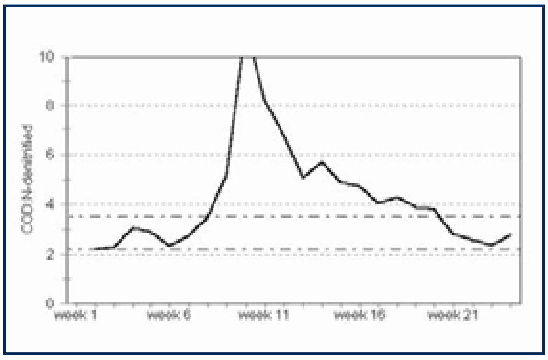


Figure 15 Start-up COD/N-removal

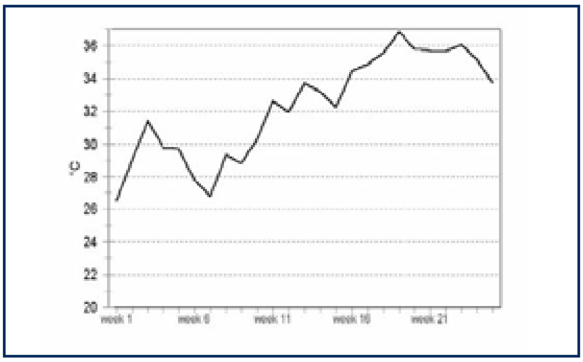


Figure 16 Start-up temperature

Continuing operation

The results for 2002 show continued stable efficient operation [2]. The large fluctuations in feed nitrogen continued ranging from 200-750 kg/day in a random pattern (Figure 19). During the second half of 2002 denitrification efficiency was raised from 60-80% to approximately 90% by increasing the methanol dosage. During that period ammonia removal was on average above 95%.

The influent ammonia nitrogen varied from 700-1200 mg/l and was above 1000 mg/l the majority of the time. Effluent concentrations stayed in the range targeted by the operations staff. Depending on the process settings, effluent ammonia nitrogen concentrations ranged from 10-90mg/l and averaged below 50 mg/l (Figure 19).

3 Operating experience in The Netherlands

The plot of the amount of nitrogen fed as compared to the amount nitrified and amount denitrified showed a steady upward trend despite the obstacles encountered (Figures 17 and 18).

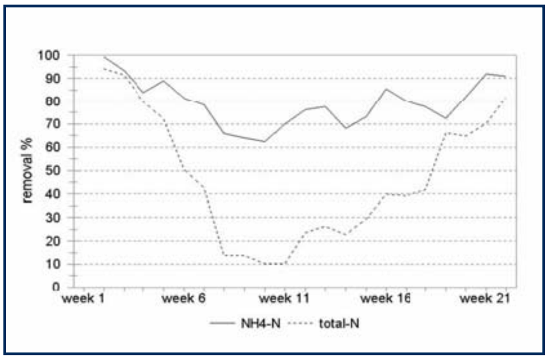


Figure 17 Start-up removal efficiencies

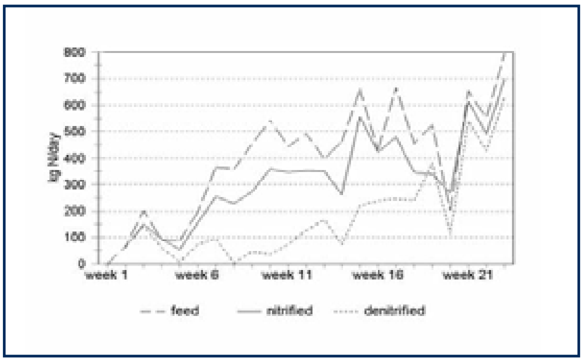


Figure 18 Start-up influent load effluent removal

The Rotterdam SHARON system is controlled to remove nitrogen via nitrite, which requires an oxic hydraulic retention below 2 days. At an oxic hydraulic retention time of approximately 1.5 days the COD/N ratio as methanol consumed illustrates clearly the metabolic pathway from ammonia via nitrite to nitrogen (Figure 21).

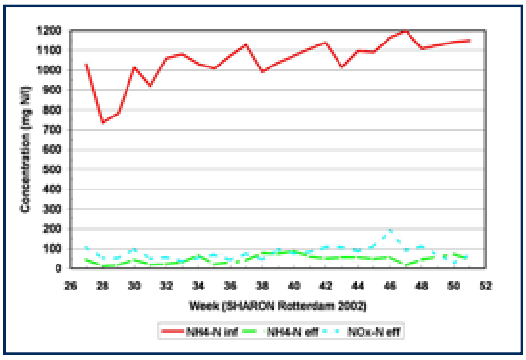


Figure 19 Continuous operations influent effluent

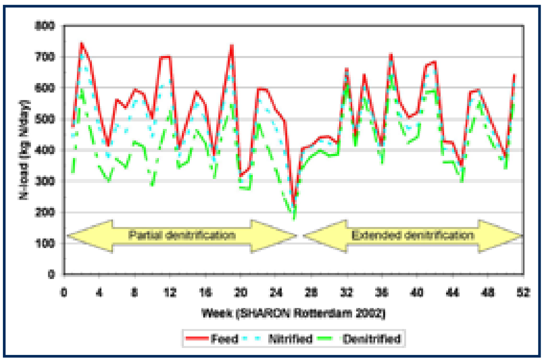


Figure 20 Continuous operations influent and effluent fluctuations

From 1999 through 2000 the SHARON process had a very beneficial effect on the main stream effluent lowering the effluent ammonia from an average 6.2 mg/l to 2.1 mg/l and total nitrogen from an average 7.5 mg/l to 3.9 mg/l (Figure 22).

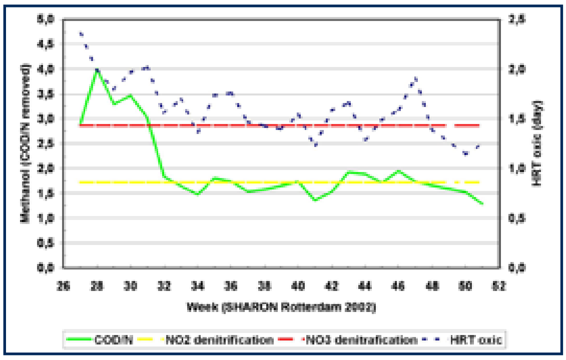


Figure 21 Continuous operations COD/N-removal nitrite pathway

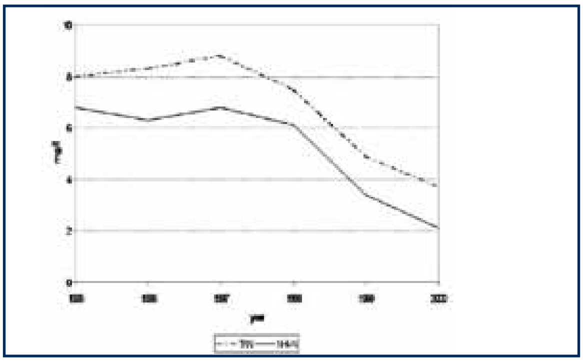


Figure 22 Continuous operation 1995 - 2000 effluent

3 Operating experience in The Netherlands

Other facilities

The success of the operations at Utrecht and Rotterdam has led other waterboards in the Netherlands to implement the SHARON process. SHARON was included in successful tenders for the Dutch cities of Zwolle, Beverwijk and Groningen. The system at Beverwijk (Figure 23) will shortly become operational whilst Zwolle (Figure 24) is under construction. The SHARON plant at Zwolle is currently being commisioned.

SHARON systems for the city of Groningen and New York City are currently in the planning stage. We believe, as others learn of this remarkable cost effective process for side stream treatment of high strength nitrogen bearing recycle streams, the reference list will grow.

Conclusions

- The SHARON process, which preferentially selects Nitroso-genera bacteria and removes total nitrogen by means of a hitherto unutilised metabolic pathway, has been successfully demonstrated full scale at two facilities for a number of years. The hitherto unused metabolic pathway is partial oxidation of ammonia to nitrite and then reduction of nitrite and followed by reduction of nitrite to nitrogen.
- The ability to select Nitrosomonas and other Nitroso-genera bacteria over Nitrobactor and other Nitro-genera bacteria has been proven.
- Demonstrated N-removal efficiencies over 90% are achieved.
- Control of the process pH by the production of alkalinity generated by denitrification has been proven.
- The production of heat in the SHARON reactor due to the rapid conversion of high nitrogen concentrations is in most cases sufficient to allow designs without ancillary heat input from external sources.
- The hitherto unutilised metabolic pathway, partial oxidation of ammonia to nitrite and reduction of nitrite to nitrogen, has been proven to provide the anticipated savings of a 25% reduction in aeration power consumption capital cost. A 40% reduction in the use of Biological Oxygen Demand (BOD) chemicals and associated operating and capital costs are also realised.

The SHARON process in full scale operation is very stable despite wide fluctuations in influent flow and total suspended solids. It also significantly improves mainstream nitrogen effluent quality.

Figure 23 SHARON® Beverwijk (1.200 kg Nkj/d)

Figure 24 SHARON® Zwolle (410 kg Nkj/d)

References

[1] Overview: Full Scale Experience of the SHARON Process for the Treatment of rejection water of Digested Sludge Dewatering; R. van Kempen, J. W. Mulder, C. A. Uijterlinde, and M. C. M. van Loosdrecht; Water Science and Technology: VOL 44 NO 1 pp145-152 © IWA Publishing.

[2] Full Scale Operation of the SHARON Process for the Treatment of Rejection Water of Digested Sludge Dewatering; J. W. Mulder, M. C. M. van Loosdrecht, C. Helllinga, and R. van Kempen; Water Science and Technology VOL 43 NO 11 pp127 134 © IWA Publishing and the authors.

4 Reference list

Project SHARON WWTP Garmerwolde (The Netherlands)
Client Waterboard Noorderzijlvest
Year 2004
Description A system for the treatment of nitrogen rich wastewater (centrate and condensate) produced during dewatering of digested sludge and sludge drying. The capacity of WWTP Garmerwolde is 300.000 p.e. Turnkey realisation.

Project SHARON WPCP Wards Island, New York City (USA)
Client Metcalf & Eddy of New York, Inc. / New York City Department of Environmental Protection
Year 2003 - 2007
Description A system for the treatment of nitrogen rich wastewater (centrate) produced during dewatering of digested sludge. The capacity of WPCP Wards Island is 285 MGD. The SHARON system is currently under design, construction scheduled for 2005/2006.

Project SHARON WWTP Beverwijk (The Netherlands)
Client Waterboard Uitwaterende Sluizen
Year 2002-2003
Description A system for the treatment of nitrogen rich wastewater (centrate and condensate) produced during dewatering of digested sludge and sludge drying. The capacity of WWTP Beverwijk is 326.000 p.e. Preparation, realisation, maintenance and guaranty period.

Project SHARON WWTP Zwolle (The Netherlands)
Client Waterboard Groot Salland
Year 2001-2003
Description A system for the treatment of nitrogen rich wastewater (centrate) produced during dewatering of digested sludge. The capacity of WWTP Zwolle is 200.000 p.e. Preparation and construction supervision.

Project SHARON pilot test MAV Gent (Belgium)
Client Jan de Nul, Aalst
Year 2001
Description A system for the treatment of nitrogen rich wastewater produced during digestion of organic waste. Realisation pilot test (4 months)

Project SHARON pilot test WWTP Garmerwolde (The Netherlands)
Client Zuiveringsbeheer Provincie Groningen
Year 1999
Description A system for the treatment of nitrogen rich wastewater (centrate) produces from dewatering of digested sludge. Realisation pilot test (3 months).

Project SHARON pilot test Biopower (Belgium)
Client Biopower
Year 1999
Description A system for the treatment of nitrogen rich wastewater produced from digestion of pig manure. Realisation pilot test (12 months).

Project SHARON pilot test WWTP Deurne at Antwerpen (Belgium)
Client NV Aquafin
Year 1999
Description A system for the treatment of nitrogen rich wastewater (centrate and condensate) produced during dewatering of digested sludge and sludge drying. Realisation pilot test (3 months).

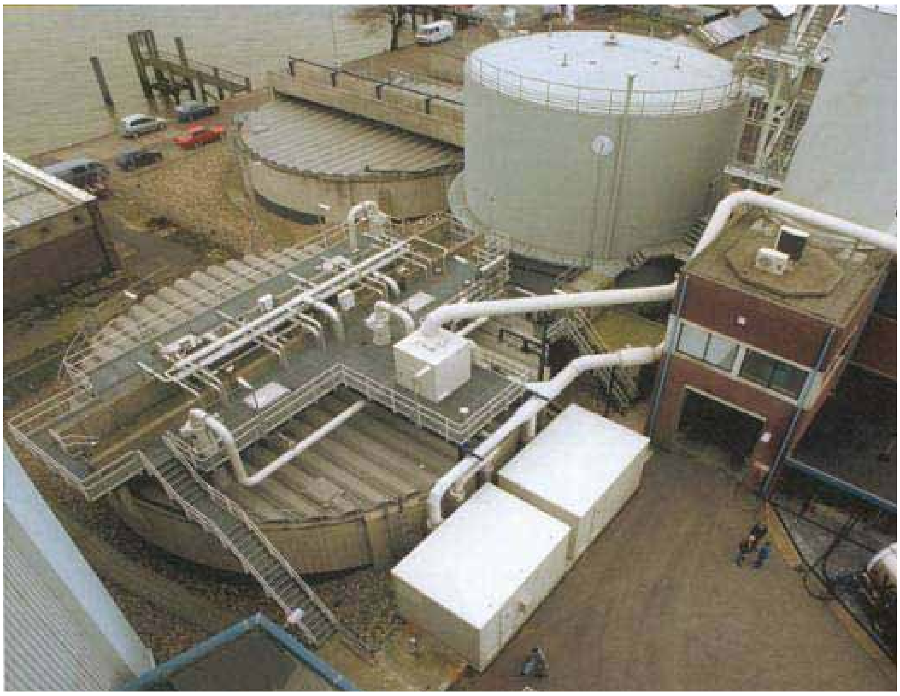
4 Reference list

Project	SHARON pilot test leachate treatment landfill Schinnen (The Netherlands)
Client	Essent Milieu v/h AVL Deponie Limburg
Year	1999
Description	A system for the treatment of nitrogen rich leachate. Realisation pilot test (3 months).

Project	SHARON WWTP Rotterdam-Dokhaven (The Netherlands)
Client	Zuiveringschap Hollandse Eilanden en Waarden
Year	1997-1998
Description	A system for the treatment of nitrogen rich wastewater (centrate) produced during dewatering of digested sludge. The capacity of WWTP Rotterdam-Dokhaven is 470.000 p.e. Preparation including the tender documents.

Project	SHARON WWTP Utrecht (The Netherlands)
Client	Hoogheemraadschap De Stichtse Rijnlanden
Year	1997
Description	A system for the treatment of nitrogen rich wastewater (centrate) produced during dewatering of digested sludge. The capacity of WWTP is 400.000 p.e.

SHARON - Dokhaven, Rotterdam (NL)



Services

Civil engineering

Domestic waste water

Project management

Process engineering

Waste water technology

Client

ZHEW water authority (NL)

Date

1997 - 1999

New legislation for nitrogen removal required optimisation of the Dokhaven WWTP of Rotterdam. This WWTP was designed as a two-stage process. This is well suited to Biological Oxygen Demand (BOD) removal as well as nitrification. However denitrification in the second stage is poor due to BOD shortage and a high sludge loading rate.

A study of the nitrogen balance of the Waste Water Treatment Plant (WWTP) showed that a significant fraction of the nitrogen is recirculated from the sludge digestion (so-called rejection water) towards the activated sludge tanks. This amounts to 15 % of the total nitrogen load of the WWTP. Therefore removing this load will directly result in an equivalent decrease of the total nitrogen load in the effluent.

Several techniques for treatment of the rejection water were evaluated, including lab test and pilot tests at large WWTP's. This research was initiated by STOWA (the Dutch foundation for applied water research). The patented SHARON process was identified as the most cost-effective technique. It involves a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rates, nitrite oxidisers are washed out of the system whilst ammonia oxidisers can be maintained. This results in nitrogen removal over nitrite instead of nitrate. Nitorgen removal with SHARON via nitrite has the following advantages:

- oxidation to nitrite saves 25% of the aeration energy;
- denitrification of nitrite saves 40% on BOD addition;
- denitrification of nitrite at high temperatures reduces sludge production by 50%;
- simple process with high process stability.

Because there was no area available for extension, a post-thickener had to be taken out of operation and was converted into a SHARON reactor. The SHARON system has been successfully in operation since 1999. Following the implementation of SHARON, the total Nkj discharge load of the Dokhaven WWTP dropped by 40%. As a result the water authority ZHEW is able to meet the required nitrogen removal demands.

SHARON - Utrecht (NL)

Services
Civil engineering

Domestic waste water

Project management

Process engineering

Waste water technology

Client
HDSR water authority (NL)

Date
2002 - 2003

New legislation for nitrogen removal required optimisation of the Utrecht Waste Water Treatment Plant (WWTP) which is operated by the HDSR water authority. This WWTP was designed as a two-stage process. This is suitable for Biological Oxygen Demand (BOD) removal, nitrification and denitrification. However denitrification in the second stage is poor due to BOD shortage and a high sludge loading rate.

A study of the nitrogen balance of the WWTP showed that a significant fraction of the nitrogen is recirculated from the sludge digestion (so-called rejection water) towards the activated sludge tanks. This amounts to 15 % of the total nitrogen load of the WWTP. Removing this load will directly result in a significant decrease of the total nitrogen load in the effluent.

Several techniques for treatment of the rejection water were evaluated, including lab and pilot tests at large WWTPs. This research was initiated by STOWA (the Dutch foundation for Applied Water Research). The SHARON process pointed out to be the most cost-effective technique. SHARON was originally developed at the Technical University of Delft (TUD). It involves a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rate nitrite oxidisers are washed out of the system while ammonia oxidisers can be maintained, resulting in nitrogen removal over nitrite instead of nitrate.

Nitrogen removal with SHARON via nitrite has the following advantages:
- oxidation to nitrite saves 25% of the aeration energy;
- denitrification of nitrite saves 40% on BOD addition;
- denitrification of nitrite at high temperatures reduces sludge production by 50%;
- simple process with high process stability.

After successful laboratory tests it was decided to design and construct a full scale process without performing an intermediate pilot test. Grontmij Water & Waste Management designed, built and commissioned the SHARON plant of WWTP Utrecht.

The SHARON system has been successfully in operation since 1999. Since the implementation of SHARON the total nitrogen discharge load of the Utrecht WWTP dropped by 30%. As a result the HDSR water authority is able to meet the strict nitrogen discharge standards.

SHARON - Zwolle (NL)

Services
Civil engineering

Domestic waste water

Project management

Prosess engineering

Waste water technology

Client
Groot Salland water authority (NL)

Date
2002 - 2003

New legislation for nitrogen removal required optimisation of the Zwolle Waste Water Treatment Plant (WWTP). The water authority SAL is responsible for the treatment of wastewater in a region situated in the Eastern Netherlands.

The sludge dewatering plant at Zwolle WWTP processes more than half of the sludge produced in the area managed by SAL. The sludge, which is digested at various locations, is dewatered by means of 2 centrifuges. This partial flow is nitrogen rich and represents a daily nitrogen load of 20% of the nitrogen load of the WWTP. Removing this load will directly result in a significant decrease of the total nitrogen load in the effluent.

Several techniques for treatment of the rejection water were evaluated, including lab test and pilot tests at large WWTP's. This research was initiated by STOWA (the Dutch foundation for Applied Water Research). The patented SHARON was identified as the most cost-effective technique. SHARON was originally developed at the Technical University of Delft.

SHARON involves a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rate nitrite oxidisers are washed out of the system while ammonia oxidizers can be maintained, resulting in nitrogen removal over nitrite instead of nitrate. Nitrogen removal with SHARON via nitrite has the following advantages:

• oxidation to nitrite saves 25% of the aeration energy;
• denitrification of nitrite saves 40% on BOD addition;
• denitrification of nitrite at high temperatures reduces sludge production by 50%;
• simple process with high process stability.

After an extensive comparison of different side stream technologies it was decided to build a SHARON system.

Grontmij designed the system, assisted the water authority with the selection of the contractors and supported the construction supervision. The SHARON system at Beverwijk WWTP is now operational and contributes to improved nitrogen removal at Zwolle WWTP and in the area controlled by the SAL water authority.

SHARON - Beverwijk (NL)

Services
Civil engineering

Domestic waste water

Project management

Prosess engineering

Waste water technology

Client
HHNK water authority (NL)

Date
2002 - 2003

New legislation for nitrogen removal required optimisation of the Beverwijk Waste Water Treatment Plant (WWTP). The water authority HHNK is responsible for the treatment of waste water in the region to the North of Amsterdam. Waste water sludge produced at the WWTP's in this region is dried at a central location situated next to Beverwijk WWTP. The condensate produced during the drying process is nitrogen rich and discharged to the Beverwijk WWTP.

A study of the nitrogen balance of the WWTP showed that a significant fraction of the nitrogen is recirculated from the sludge digestion (so-called rejection water) towards the activated sludge tanks. Together with the condensate of the drying process, this amounts to 30% of the total nitrogen load of the WWTP. Removing this load will directly result in a significant decrease of the total nitrogen load in the effluent.

Several techniques for treatment of the rejection water were evaluated, including lab and pilot tests at large WWTPs. This research was initiated by STOWA (the Dutch foundation for Applied Water Research). The patented SHARON process was identified as the most cost-effective technique.

SHARON was originally developed at the Technical University of Delft (TUD).It involves a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rate, nitrite oxidisers are washed out of the system while ammonia oxidisers can be maintained, resulting in nitrogen removal over nitrite instead of nitrate. Nitrogen removal with SHARON via nitrite has the following advantages:

- oxidation to nitrite saves 25% of the aeration energy;
- denitrification of nitrite saves 40% on BOD addition;
- denitrification of nitrite at high temperatures reduces sludge production by 50%;
- simple process with high process stability.

After successful laboratory tests it was decided to design and construct a full scale process without performing an intermediate pilot test. Grontmij designed the system, assisted the water authority with the selection of a general contractor and with construction supervision and is responsible for process commissioning.

The SHARON system of Beverwijk WWTP has been operational since 2003. It is expected that the implementation of SHARON will result in an overall 2% nitrogen discharge reduction of the total area serviced by the HHNK water authority.

SHARON - New York (USA)

Services
Civil engineering

Domestic waste water

Project management

Process engineering

Waste water technology

Client
Metcalf & Eddy

Date
2003 - 2004

New York City has developed a comprehensive nitrogen management plan to reduce the aggregate effluent nitrogen loading from Water Pollution Control Plants (WPCPs) to the Upper East River and Jamaica Bay. Separate centrate treatment has been identified as an integral part of this plan, since up to 40% of nitrogen loading at WPCPs with centralized dewatering facilities is directly attributable to centrate loading.

Pilot research by the New York City Department of Environmental Protection related to nitrogen removal and other related operational issues, showed SHARON had multiple benefits. In particular, it was demonstrated that SHARON was a highly efficient, cost effective and environmentally sound process for the removal of high levels of nitrogen from centrate.

SHARON concerns a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rate, nitrite oxidisers are washed out of the system while ammonia oxidisers can be maintained, resulting in nitrogen removal over nitrite instead of nitrate. Nitrogen removal with SHARON via nitrite has the following advantages:

- oxidation to nitrite saves 25% of the aeration energy;
- denitrification of nitrite saves 40% on BOD addition;
- denitrification of nitrite at high temperatures reduces sludge production by 50%;
- simple process with high process stability.

New York City considers it prudent to evaluate this innovative, yet proven, technology at demonstration scale to determine its applicability as part of the long term nitrogen reduction plan for New York City. This will also verify the potential cost savings that will be realised as a result of implementation of this process.

Under the management plan, New York City intends to build a demonstration plant for the SHARON system at Wards Island WPCP. This SHARON will treat centrate produced at the plant in the sludge dewatering facility. This facility dewaters anaerobically digested sludge produced at Wards Island and at two other WPCPs.

Grontmij, who is the owner of the proprietary SHARON technology, assists Metcalf & Eddy of New York, Inc. in the preparation of the design of the SHARON for Wards Island WPCP. Construction of the system, with a capacity of 5.000 kg NH_3-N per day, is currently being undertaken.

SHARON - Gammerwolde (NL)

Services
Civil engineering

Domestic waste water

Project management

Prosess engineering

Waste water technology

Client
Waterschap Noorderzijlvest

Date
2004 – 2006

The wastewater treatment plant (WWTP) at Garmerwolde in the Netherlands is being refurbished to meet future effluent standards. Part of the refurbishment is the construction of a SHARON system for the treatment of flows produced at the sludge dewatering and sludge drying facilities at Garmerwolde.

At WWTP Garmerwolde, locally produced sludge is anaerobically digested and, together with sludge imported from other facilities, dewatered and dried. The filtrate produced in the sludge dewatering process together with the condensate produced in the sludge drying process contribute approximately 34% of the total nitrogen load to Garmerwolde WWTP.

The water board Noorderzijlvest, which owns the Garmerwolde WWTP, has selected the SHARON process as preferred method for filtrate and condensate treatment on the basis of overall treatment cost, high guaranteed ammonia removal efficiency, stable operations and proven track record.

SHARON is a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rate nitrite oxidisers are washed out of the system while ammonia oxidisers can be maintained, resulting in nitrogen removal over nitrite instead of nitrate. Nitrogen removal with SHARON via nitrite has several advantages:

- oxidation to nitrite saves 25% on aeration energy;
- denitrification of nitrite saves 40% on BOD addition;
- denitrification of nitrite at high temperatures reduces sludge production by 50%;
- simple process with high process stability.

Grontmij, as main contractor and owner of the proprietary SHARON technology, is responsible for the design and construction of the SHARON system and will operate this part of the treatment process for one year.

SHARON - The Hague (NL)

Services
Civil engineering

Domestic waste water

Project management

Prosess engineering

Sewage sludge treatment

Waste water technology

Client
Delfluent Services BV

Date
2004 – 2005

Under European regulation, The Netherlands was required to achieve an overall nitrogen removal efficiency of 75% in 2006 for urban wastewater. The waste water treatment plant (WWTP) at Houtrust in The Hague, with a capacity of 930.000 population equivalents, is a significant contributor to nitrogen discharge in The Netherlands. Currently no nitrogen is removed at Houtrust WWTP and consequently the plant is being refurbished to meet European nitrogen removal standards.

To decrease the nitrogen load in the effluent in the period up to 2008, the Delfland water board, together with its private operating partner Delfluent, has selected the SHARON process for centrate treatment. The SHARON process was chosen for its proven nitrogen removal efficiency, low operating and construction cost and proven process stability. Grontmij is implementing the SHARON process at Houtrust WWTP as a turnkey project, and guarantees to have the system available within six months of the contract execution date.

SHARON is a high active process for nitrogen removal operating without sludge retention. Due to differences in growth rate, nitrite oxidisers are washed out of the system while ammonia oxidisers can be maintained, resulting in nitrogen removal over nitrite instead of nitrate.

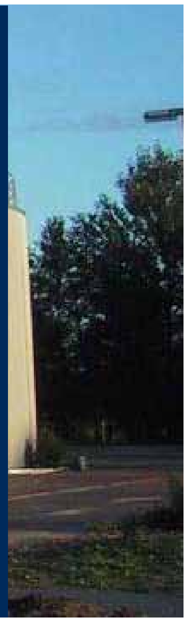
Nitrogen removal with SHARON via nitrite has the following advantages:

- oxidation to nitrite saves 25% of the aeration energy;
- denitrification of nitrite saves 40% on BOD addition;
- reduces sludge production by 30%;
- reduces CO_2-emission by 20%;
- simple process with high process stability.

Prepared by:
Grontmij Limited

Grove House
Mansion Gate Drive
Leeds
LS7 4DN

T 0113 262 0000
F 0113 307 3004



Grontmij

www.grontmij.co.uk