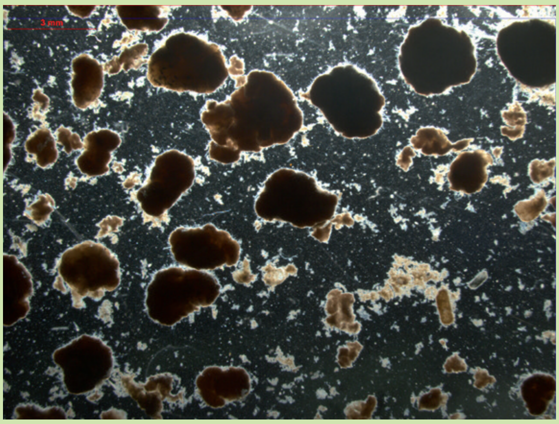
CENIRELTA Cost effective nitrogen removal from wastewater with low temperature Anammox

CENIRELTA is co-financed by LIFE+, the financial instrument for the environment of the European Commission (ENV/NL/785)

Duration:
2013-2016
Budget:
Total budget: €2.500.000,- of which 50% subsidy.
Goal:
To demonstrate that CENIRELTA provides a suitable technology for nitrogen removal from (municipal) wastewater and is more attractive than present techniques being used concerning costs and sustainability.
Location:
WWTP Dokhaven, Rotterdam, The Netherlands
Partners:
RWA Hollandse Delta, Paques BV, STOWA
Project website:
www.cenirelta.eu

At the wastewater treatment plant Rotterdam Dokhaven in the Netherlands, project partners Regional Water Authority (RWA) Hollandse Delta, Paques BV and STOWA are demonstrating an innovative technology for nitrogen removal from municipal wastewater: mainstream Anammox. The objective is to improve the effectiveness and resilience of the traditional treatment process, while at the same time reducing its energy consumption.



With the contribution of the LIFE Programme of the European Union

waterschap Hollandse Delta

ABOUT CENIRELTA

Wastewater treatment

Every day we consume about 120 liters of drinking water per person for activities such as showering, flushing the toilet and doing the dishes. Polluted (waste)water that results from this is collected in a sewer system and transported to a central location. It is of great importance for public health and the environment that the wastewater is purified before it is discharged into surface water. This purification process takes place in a wastewater treatment plant (WWTP).

Among other components, an important pollutant in wastewater is nitrogen. High concentrations of nitrogen in surface water lead to an overabundance of nutrients, so called eutrophication. Eutrophication can lead to a bloom of small organisms such as algae. Since algae also consume oxygen the oxygen concentration in the water can get so low that higher organisms such as fish are harmed.

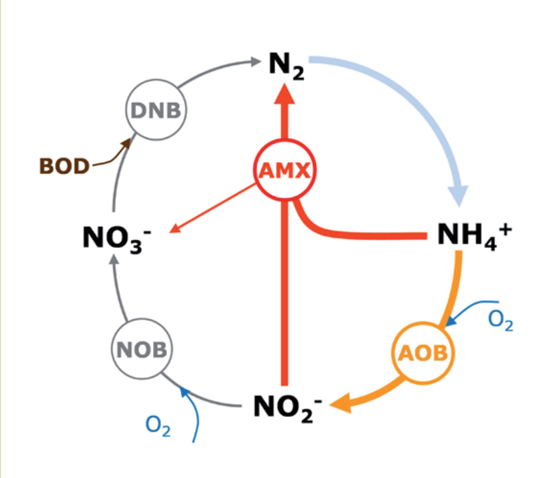
Nitrogen removal and Anammox bacteria

In conventional domestic wastewater treatment plants nitrogen is removed from the wastewater biologically by different groups of bacteria. The nitrogen, present in wastewater as dissolved ammonium (NH_4^+), is first converted into nitrite (NO_2^-) by ammonia oxidizing bacteria (AOB). Subsequently the nitrite is converted into nitrate (NO_3^-) by nitrite oxidizing bacteria (NOB). Finally, the nitrate is converted by denitrifying bacteria (DNB) into harmless nitrogen gas (N_2) and released into the air. The air we breathe consists of about 80% nitrogen. A drawback of the conventional nitrogen removal process is that the bacteria consume a lot of oxygen (O_2) and organic matter (BOD) to complete the removal. In practice this leads to high energy consumption for the wastewater treatment. In the late 1980's, by coincidence, a new species of bacteria was discovered, the socalled Anammox bacteria.

Anammox (Anoxic Ammonia Oxidation) bacteria are capable of converting ammonium and nitrite directly into nitrogen gas. With Anammox a huge shortcut can be made in the nitrogen cycle, saving up to 60% of aeration energy compared to the conventional removal route. Besides this no organic material is required for denitrification. This saved organic matter can be utilized otherwise, for example for digestion and additional biogas and energy production.

The Anammox process

Granular activated sludge consists of an anoxic core with Anammox bacteria and an aerobic outer layer with ammonia oxidizing bacteria (AOB). The AOB convert part of the NH_4^+ into NO_2^-. These two components together are converted into harmless N_2 gas by Anammox bacteria. Granules are maintained in the system, while smaller constituents such as flocs are flushed out continuously.



PROJECT SCOPE AND OBJECTIVES

Since its discovery scientists have investigated Anammox bacteria to use it to our advantage. They have succeeded for specific wastewater streams with high temperatures (35 °C) and high nitrogen concentrations (> 1.000 mg/l). Under these circumstances Anammox technology is now a proven technology and applied in full-scale treatments plants worldwide.

The next challenge ahead is to implement Anammox technology for the treatment of "normal" municipal wastewater. In this type of wastewater, the nitrogen concentrations (30-40 mg/l) and temperatures (8-25 °C) are severely lower. Under these circumstances Anammox bacteria are less active compared to other bacteria species and can become overgrown. The challenge for implementing Anammox technology in the mainstream of a WWTP is to create circumstances in which Anammox bacteria can survive and other undesirable bacteria are suppressed. Exploratory research has already proven the feasibility of mainstream Anammox. The final step is to scale up the technology and implement it in a full-scale WWTP.

WWTP Dokhaven, Rotterdam, The Netherlands

RWA Hollandse Delta, Paques and the Dutch Foundation for Applied Water Research (STOWA) are working together in an innovative research project aiming at demonstrating the effectiveness and resilience of mainstream Anammox technology. The CENIRELTA (Cost Effective Nitrogen Removal from Wastewater with Low Temperature Anammox) project is supported with a European Life+ grant.

The CENIRELTA project has two broad objectives:

The first objective is to demonstrate that the Anammox process provides an *effective* and *robust* technology for the removal of nitrogen from municipal wastewater, thereby reducing the nitrogen emission into the surface water.

The second objective is to demonstrate that the CENIRELTA concept provides a *cost-efficient* and *sustainable* treatment process. This is expressed by lower investment costs due to a compact installation and lower energy consumption for the wastewater treatment process combined with higher energy production via sludge digestion and biogas production.
Ideally, the energy production is compensating for the consumption, resulting in an energy neutral system.

METHODOLOGY

In the CENIRELTA project a demonstration reactor (4 m^3) is operated at WWTP Rotterdam Dokhaven in the Netherlands. The reactor processes a small quantity of municipal wastewater from the mainstream of the WWTP. The reactor contains so-called granular activated sludge in which Anammox and AOB bacteria are present. Together they remove the nitrogen from the wastewater. The demonstration installation is linked to the normal purification process. This parallel connection implies that the process in the reactor experiences the same 'inconveniences' which occur in the regular purification process (fluctuations in wastewater flow, composition and temperature).
In addition to this, a business case has been made to support the cost-efficiency and sustainability claims.

RESULTS AND CONCLUSIONS

CENIRELTA is an excellent example of an innovative project between companies, government and knowledge institutions. In this project, the RWA has co-invested in the development of an important technology and could even play the part of being a launching customer if this technique is applied on a full scale basis. STOWA has ensured the contribution and sharing of knowledge from other RWA's.

Paques played the part of technology developer and supplier, whose objective was to apply the technology on a commercial scale.

TU Delft provided not only fundamental knowledge but also adjacent research at laboratory scale. One person has graduated on this subject and another person is working towards graduation. Without this crucial cooperation within the golden triangle, this project would not have gotten off the ground and building blocks for further development would not have been laid.

During the project, al lot of progress towards full scale application has been made. It is also clear that there are still aspects that need further development. One of the most important conclusions made from this demonstration project is that economic analysis has shown that CENIRELTA is indeed cheaper and more sustainable than the present treatment technologies.

The technology cannot be applied to the highly loaded WWTP Dokhaven in the short term. However, the obstacles and ways of solving them have been defined to enable the technique to be applied there.

As far as the technology is concerned, the conclusion can be made that under summer conditions (water temperature <17 °C), total-nitrogen concentration achieved with the CENIRELTA demonstration installation in the effluent is approximately equal to that of the WWTP Dokhaven. Moreover, there is still room to achieve improvement in the nitrogen removal by further optimisation of the design and management of the process.

Under winter conditions (water temperature <17 °C) it was still possible to show nitrogen removal, however it has not yet been possible to demonstrate a stable and sufficiently efficient removal. On the basis of observations and the information collected, it is not possible to establish whether this can be due exclusively to the low temperature or whether a combination of other factors have played a more dominant role.
All results, conclusions and recommendations will be more extensively described in the STOWA Final Report. (www.stowa.nl).

CENIRELTA Mainstream Anammox demonstration reactor

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