# Sustainable Solution for Phosphate and Ammonium Removal

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***Over the past years, the ANAMMOX® system demonstrated successfully to be a simple and robust method for nitrogen removal, without the need of a carbon source and reducing energy costs by 50%. The PHOSPAQ process removes phosphate from the effluent by formation of struvite, which is a valuable fertiliser. The combination of these two processes is an effective and sustainable solution for removing N and P from waste water, at low total cost of ownership. How does it work in practice? This article takes a closer look at one of Paques' clients.***

*Waste water treatment plant at Aviko Steenderen*

### Case Study of Aviko Steenderen (Potato Processing Industry)

### The Challenge

The AVIKO potato processing plant in Steenderen, the Netherlands, produces a wide variety of potato products. As a consequence, waste water is produced that contains proteins, starch and phosphate, equaling an amount of 160,000 population equivalent.

Already since 1982 this waste water is treated in a dedicated treatment plant, based on anaerobic UASB technology, located on the premises of the municipal STW Olburgen. In the UASB reactors the organic components (COD) are converted into biogas that is reused by conversion into electricity and heat. The effluent coming from the UASB reactors is discharged to the sewage treatment plant. Although most of the COD-load has been removed by the anaerobic treatment plant, this effluent still contains considerable amounts of COD, $NH_4$ and $PO_4$ which represents discharge costs of over € 1,5 million per year.

The owner and operator of this dedicated treatment plant for AVIKO's waste water is the operating company Waterstromen.

Due to new regulations (EWFD), the municipal STW Olburgen had to reduce the nitrogen and phosphate discharge in their final effluent. Since the major part of the nitrogen and phosphate load of the sewage treatment originates from the UASB reactors, it was decided to give Waterstromen the task to reduce the phosphate and nitrogen content of the anaerobic effluent. Therefore they looked for a suitable process to remove these high amounts of phosphate and nitrogen. The challenge was to minimise the total cost of ownership and to maximise sustainability.

- **Compliance to new regulations for N and according to EWFDz**
- **Minimise total cost of ownership**
- **Maximise sustainability**

### The Solution

A comprehensive feasibility study by Waterstromen resulted in the selection of the PHOSPAQ-process in combination with the ANAMMOX®-process to achieve their goals instead of using a conventional activated sludge process in combination with iron dosing.

### Phosphate Removal With PHOSPAQ

Effluent from the UASB reactors combined with a small reject water stream coming from sludge dewatering on the STW are introduced in the PHOSPAQ reactor. The PHOSPAQ reactor can be described as an aerated crystallization reactor where phosphorous and residual COD removal is combined. Under addition of MgO, phosphate is removed by precipitation as struvite.

Synergetic advantages are obtained by combining P- and COD-removal in the PHOSPAQ reactor. Simultaneous aeration of the reactor allows the additional biological conversion of residual COD, but also provides for the mixing required to obtain a good struvite quality. In addition, it provides for stripping of $CO_2$ that raises the pH and stimulates the struvite formation. The struvite produced, is harvested from the bottom of the reactor. The struvite complies with EU standards for fertiliser and can be used as slow-release fertiliser.

*Anammox granular sludge*

### Ammonium Removal With ANAMMOX®

Next step is the ANAMMOX® reactor where in one single stage ammonium is directly converted into nitrogen-gas by a combination of nitritation and anammox bacteria.

Compared to conventional nitrification-denitrification, the conversion of ammonium does not require organic carbon. Therefore a bypass of the UASB reactors to supply COD is avoided and thus a maximum generation of biogas is secured. Furthermore, approximately 40%-50% energy is saved because relatively little aeration is required.

After the ANAMMOX® reactor water is discharged to the sewage works where the waste water is further treated to reach surface water discharge quality. The construction of the plant was completed early 2006.

- **PHOSPAQ process removes phosphate as struvite, which is suitable as fertiliser**
- **ANAMMOX® process removes ammonium without the use of an electron donor and at reduced power consumption**

*ANAMMOX® pilot plant for on-site testing*


*Process layout for application of ANAMMOX® as water post-treatment of sludge digestion*

## The Benefits

This plant with both PHOSPAQ and ANAMMOX® processes is in operation since spring 2006. The plant provides Waterstromen a yearly saving on discharge costs of over € 1,5 million. Removal of phosphorous and ammonium is over 80% and over 90% respectively. As a consequence, STW Olburgen complies with the stricter discharge limits for N and P.

Compared to conventional activated sludge process where iron-salts are dosed for phosphate removal, the combination of PHOSPAQ and ANAMMOX® processes provides the following advantages:

- An extra 1,5 GWh net electric power is annually produced because no bypass of the UASB reactors is necessary to provide a carbon source for denitrification and therefore the biogas production is maximised;
- Yearly 400 ton dry solids of struvite is produced. The struvite has been tested and found suitable as substitute for commercial fertilisers;
- Due to the enhanced conversions of the PHOSPAQ and ANAMMOX® processes, the total reactor volume is only 1,200 $m^3$. Conventional treatment would have required a volume of approximately 7,000 $m^3$;
- Total sludge production is reduced by 600 tons dry solids annually because sludge growth in an autotrophic process like ANAMMOX® is substantially lower compared to heterotrophic processes like denitrification. Moreover, instead of biological surplus sludge and iron-phosphate, the formed struvite is a valuable base product.

**• Annual saving on discharge costs of over € 1,5 million**
**• Comply with stricter EU regulations for N and P**
**• An additional 1,5 GWh net electric power is annually produced because no bypass of the UASB reactors is necessary to provide a carbon source for denitrification and therefore the biogas production is maximized;**
**• Production of 400 ton/year suitable fertiliser**
**•Compact process, more than 5 times less reactor volume needed**
**•600 tons less sludge production per year**

| **Facts & Figures Aviko potato processing plant** | |
|---|---|
| AVIKO Potato Processing | 100 tons/h potatoes<br>Waste water stream = 160,000 p.e. |
| Anaerobic pre-treatment | 85% reduction of COD<br>Biogas conversion into heat & electricity (600 kWe) |
| UASB effluent contains | 1,600 kg COD/day<br>1,000 kg $NH_4$-N/day<br>200 kg $PO_4$-P /day |
| PHOSPAQ process | 80% $PO_4$-P reduction<br>400 tons/year struvite suitable as fertiliser<br>70% COD removal |
| ANAMMOX® process | 90% $NH_4$-N reduction |

*Struvite: a valuable base material*

## What Does The Customer Say?

Richard Haarhuis, Operational Manager of Waterstromen: "We choose the PHOSPAQ - ANAMMOX® combination because of the lowest total cost of ownership and its sustainability. We were convinced by the low power consumption, the recovery of resources and the limited space required. The performance of the plant shows we have made the right decision".

## What About The Future?

The market introduction of ANAMMOX® is progressing steadily. Paques is now building its 7th ANAMMOX® installation, while three pilot plants are operational in different parts of the world. Recently, Paques reached agreement for the design and supply of the largest effluent treatment plant for ammonium removal in the history of the company. This ANAMMOX® process reactor has capacity for the conversion of 11 tons of nitrogen per day. It will be supplied to the Meihua Group, a large Chinese producer of among others glutamate, starch and amino acids. The customer has chosen for a combination of ANAMMOX® and anaerobic water treatment with BIOPAQ®IC. The waste water treatment plant will be started up Q3 2009.

Concerning the PHOSPAQ technology, two plants have been established. Very important for the introduction of the process is that recently, the struvite product indeed is being deployed as fertiliser, resulting in extra revenues for the waste water treatment operation.

In short, PHOSPAQ and ANAMMOX® have proven to be compact, simple and robust technologies for removing phosphate and ammonium. They are substantially contributing to the line-up of Paques' sustainable and cost-effective technologies for water and gas purification systems.