# Stoke Bardolph STW Centrate Scheme

## first UK installation to utilise the Phospaq, UASB+ and Anammox technologies in a single process solution

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Located adjacent to the River Trent to the east of Nottingham, Stoke Bardolph STW serves a population equivalent of approximately 650,000. Energy is produced by sludge digestion leaving dewatering liquor as a waste stream with high concentrations of ammonia and phosphate. This represents a large fraction of the total nutrient loading on the sewage treatment works. Additionally, a trade waste with significant nutrient loading comes from a neighbouring rendering plant direct to the works to give a second stream.

*UASB+ and buffer tank under construction*
*Courtesy of NMCNomenca and Severn Trent Water*

*Lamella separator under construction*
*Courtesy of NMCNomenca and Severn Trent Water*

### Treatment process

The sludge dewatering liquors are first treated in a phosphorus removal reactor (PHOSPAQ™), while the trade waste stream is first treated in a UASB+ reactor for biogas production. The two streams are then combined and treated in an ammonia reactor (ANAMMOX®).

The first full scale trials of the Anammox process were carried out in the Netherlands in 2002 and to date there are 20 in the world. This is the first UK installation of all three technologies in a single process solution.

- ***PHOSPAQ™ reactor***: The Phospaq process is applied to recover phosphate from effluents as struvite (magnesium-ammonium-phosphate). Phosphate is becoming scarce and Phospaq is a cost-effective technology compared to, for example, dosing of iron salts. Moreover, the produced struvite is an excellent slow release fertilizer for N, P and Mg.
- ***BIOPAQ® UASB+ reactor***: In the BIOPAQ® UASB bioreactor, organic compounds are converted to biogas by bacteria in the absence of air. In this way, effluent discharge costs are reduced and at the same time green energy is produced from methane ($CH_4$) and used for power generation.
- ANAMMOX®***reactor***: The Anammox (anaerobic ammonium oxidation) process is an innovative biological process that represents a major breakthrough in nitrogen removal. It is a cost effective, robust and sustainable way of removing ammonium from wastewater and from waste gas. Compared to conventional nitrification/denitrification, operational costs are reduced by over 50% as are $CO_2$ emission levels. This brings the plant's carbon footprint down to a minimum.

### Innovation

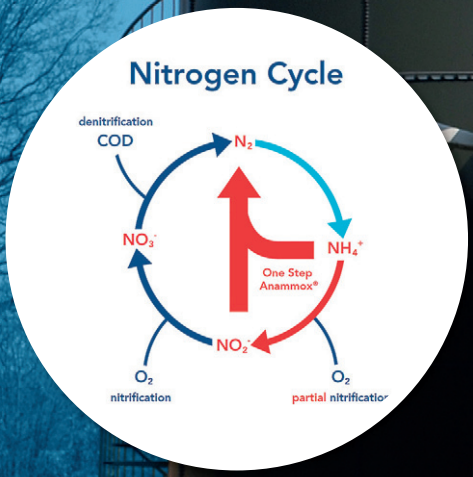
The team recognised how constructive challenge throughout the life cycle of a project has the potential to add value and drive efficiencies especially in the early stages of the project delivery.

PAQUES

# Sustainable Nutrient Removal

## PHOSPAQ™
**Efficient phosphorus recovery**

## ANAMMOX®
**Cost-effective nitrogen removal**




- 10 years operational experience
- Production of valuable slow-release fertiliser
- 60% savings on operational cost

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Using the combined knowledge and expertise the team took a holistic view of the works and early feasibility recognised the potential in carrying out the highly efficient pre-treatment of the high strength liquors. The team from Severn Trent Asset Creation and Service Delivery and NMCNomenca worked with Paques BV to introduce technologies that have been available on the continent as the first full UK scale installation incorporating all three processes.

This has removed the necessity for a further activated sludge plant (ASP) and associated treatment tanks to be constructed, achieved major CAPEX and OPEX savings and provides additional revenue streams from fertilizer production and energy generation. The footprint for the new plant is 25% of a traditional ASP with only 50% of the air demand and utilises surplus heat from CHP production and the exothermic process within the Anammox to recycle its own internal heat.

## Civil design and construction

The tank structure has been designed as a fully restrained structure assuming that the roof was cast in situ with an uninterrupted rebar cage. The construction of this would have required a lot of work both at height and in a confined area. The use of a precast roof was therefore investigated. The final design was for a majority in situ construction with a small scale precast option over the smaller confined chambers. When the main roof slab was cast this was incorporated in to the slab.

This combined option:

- Removed the issues associated with working within a confined space.
- Removed extensive working at height.
- Removed the need to use system false work in the footprint of a narrow tank.
- Reduced the critical path on the contract programme.
- More cost effective.

## Use of BIM

This project has made extensive use of BIM technology. In particular this has included the use of a full 3D dynamic model and associated outputs with all the sub-contractors contributing. Throughout the design review process the use of the 3D model has been integral in ensuring that all changes can be successfully incorporated and any pipe clashes detected. The reviews involved personnel from all disciplines including the design, construction and end user and ensured that risks were recognised and where possible designed out or clearly communicated.

The model has been used to provide full isometric drawings of pipework runs, along with automatic call offs for valves, pipework sections, lengths, bends, and materials. As the work progressed the live data was fed back into the model to check and modify any call offs and setting out positions.

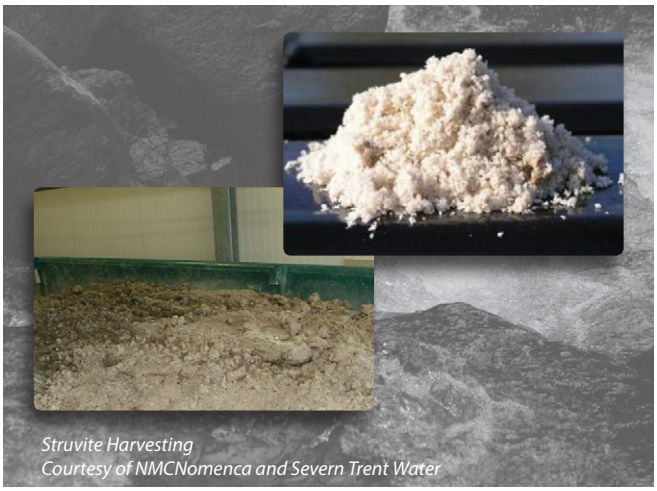
Further a section of the plant has been used to trial the use of a dynamic P&ID linked to the model which can automatically check that the mechanical layout match the P&ID and that all tagged instruments and valves are present. This has proved successful and will be incorporated into future schemes.

## Benefits

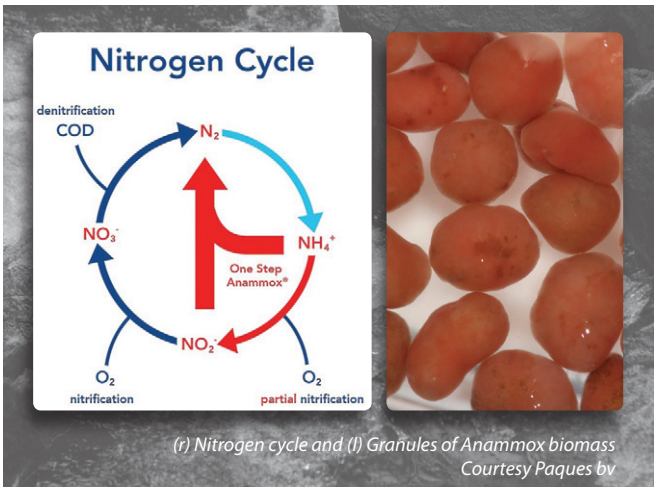
What makes this scheme/technology unique? In a conventional chemical dosing P-removal the OPEX costs are high and can result in elevated phosphorus levels in the sludge cake. The high concentration of phosphorus in the dewatering liquors lead to excessive struvite (magnesium ammonium phosphate) deposits causing significant operational and maintenance problems.

***Advantages of PHOSPAQ™***

- Combined phosphate and COD (chemical oxygen demand) removal in one reactor.



*Struvite Harvesting*
*Courtesy of NMCNomenca and Severn Trent Water*




*(r) Nitrogen cycle and (l) Granules of Anammox biomass*
*Courtesy Paques bv*

- Aeration provides the oxygen for the biological conversion of COD.
- Aeration provides optimal mixing conditions for struvite formation.
- Stripping of carbon dioxide raises the pH and stimulates struvite precipitation.
- Excellent struvite quality (in compliance with EU fertilizer regulation).

Currently at Stoke Bardolph the trade waste is treated using conventional ASP, requiring significant air demand to remove COD.

***Advantages of BIOPAQ® UASB+***

- Very efficient COD removal.
- Production of biogas, a sustainable source of energy.
- Modular system.
- Small reactor height.
- Corrosion-free design.
- Fully accessible for inspection and cleaning.
- Closed system with no odour emissions.

Currently at Stoke Bardolph STW the ammonia load from both the dewatering liquors and trade waste are treated using conventional ASP. The requirement at Stoke Bardolph for Severn Trent Water to replace the aging assets has provided the opportunity to reduce the footprint of new ASP by utilising Anammox for these high strength loads.

***Advantages of ANAMMOX®***
Compared with conventional nitrification/denitrification ASP the Anammox process offers:

- High nitrogen removal.
- No methanol dosing is needed for de-nitrification.
- Up to 60% reduction of power consumption.
- Minimal production of excess sludge.
- Up to 90% reduction of $CO_2$ emission.
- Footprint 25% of a conventional solution.

## Commercial implications

- ***Capital Expenditure (CAPEX):***
  - A saving of 40% was achieved based upon the alternative solution to provide additional ASP capacity.
- ***Operational Expenditure (OPEX):***
  - Energy savings 50% expected.
  - Maintenance savings (struvite damage): £70k/annum.
- ***Revenue:***
  - Power generation: 1,000MW hours/annum.
  - Phosphorus: 736 tonnes/annum.

## Sustainability benefits

Phosphates are the naturally occurring form of the element phosphorus. This is a depleting finite resource predominantly mined in China, North America, North Africa and Australia and it is expected that reserves will be depleted in the next 50 to 100 years.

The production of fertilizer from this treatment process is a 100% renewable source. The scheme is expected to produce approximately 2 tonnes/day which is equivalent to 2,000 tonnes/day of mined rock). It has a vastly reduced carbon footprint when compared with mined production.

The Anammox reactor operates with reduced energy input as the process utilises an efficient shortcut in the carbon cycle.

The UASB+ reactor converts organic components from wastewater into biogas consisting mainly of methane ($CH_4$) which is used for power and heat generation. It is anticipated that it will produce approximately 3MW hour/day, which is enough to power 200 houses.

## Community initiatives

At each stage of the project steps have been taken to ensure that the local community is not adversely affected by the works, this has been done through:

- Community open days including tours around site, education sessions and Q&A.
- University visits to enable completion of coursework and development of construction understanding.
- All excavated materials retained on site.
- All works contained within site boundary.
- Liaison with Burton Joyce and Stoke Bardolph parish councils.

## The future for centrate treatment

Each element of the innovative technology is suitable for use either independently or combined where similar waste streams exist. This is applicable on many of the major treatment plants across the UK, particularly in areas of high industrial applications and those with phosphorus discharge consents.

Upon completion of the installation at Stoke Bardolph there is a potential for this technology to be adopted at three other Severn Trent sites and other water companies are awaiting the results with interest.

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