Water Science and Technology **Vol 50 No 7 pp 49–52** © HSE 2004

Combined quantity management and biological treatment of sludge liquor at Hamburg's wastewater treatment plants – first experience in operation with the *Store and Treat* process

F. Laurich

HSE Hamburger Stadtentwässerung, 4-6 Banksstrasse, D-20097 Hamburg, Germany
(E-mail: *frank.laurich@hhse.de*)

Abstract Store and Treat (SAT) is a new concept for the management of ammonium-rich process waste waters at wastewater treatment plants. It combines the advantages of quantity management and separate biological treatment, whereby both operations are carried out in the same tank. Now the first full-scale application of that method was realized in Hamburg. As first experience shows the process can help to increase nitrogen removal and to reduce energy consumption.
Keywords Equalisation; nitrification; nitrogen removal; sludge liquor

Introduction

In view of today's requirements in respect to the waste water effluent quality, nitrogen is the factor most difficult to control in many waste water treatment plants. On the other hand, it is also known that ammonium-rich return flows from sludge dewatering increase the nitrogen influx load by 20 to 25%. This partial flow with its highly concentrated components and a mostly elevated temperature is particularly suitable for separate pre-treatment. However, in most cases the separate treatment costs clearly exceed the savings achieved. As a result, a sludge liquor quantity management is often implemented for economic reasons without, however, providing for a separate treatment of same.

The *Store and Treat* (SAT) process combines quantity management and biological treatment of the sludge liquor in such a manner that both processes can take place at the same time and in one and the same basin, the storage tank. Therefore, and in view of the fact that the specific quantity management continues to be of major importance because of its benefits such as equalisation, SAT is not a mere treatment process. The biological treatment is actually carried out in addition to the quantity management. It is effected in either impounding, batch or continuous operation, depending on the operating condition the storage tank happens to be in. Owing to the fact that both processes complement each other in a positive way, in many cases the desired relief of a waste water treatment plant can be achieved in a more cost-efficient manner using the SAT process than it would be possible based on mere quantity management or treatment of the sludge liquor. The method is particularly suitable for retrofitting the already existing sludge liquor storage basins for biological treatment.

Design and construction of the SAT installation at the Dradenau Wastewater Treatment Plant in Hamburg

Initial situation

At Hamburg's combined WWTPs Köhlbrandhöft/Dradenau the sludge liquor quantity obtained from digested sludge dewatering is approximately 150 m^3/hr with an NH_4-N concentration of about 1,250 mg/l. The nitrogen load reaching the biological phase together with the sludge liquor represents approximately 25% of the total load, in relation to the

TKN parameter. As a result of the quantity management of the sludge liquor, that has been operated in two storage basins (4,000 m^3 each) since 1995, the nitrogen loads from the sludge liquor, which are to be treated in the main flow of the WWTP, have been supplied to the aeration tanks already based on a timed dosage so that the nitrogen parameter control values were strictly adhered to. Excess of limit values was mainly avoided by the equalisation and levelling of peak loads. The SAT process now made it possible to implement a cost-efficient additional sludge liquor treatment. After successful testing, one of the two existing sludge liquor basins was adapted for application of the SAT method.

Design of the full-scale installation

Surveys made for Hamburg's Combined Waste Water Treatment Plants have shown that a complete nitrogen elimination is not required in the partial flow as even a partial elimination already leads to a marked relief in the biological stage, and the chosen combination with the sludge liquor quantity management strengthens this effect further. Therefore, the installation has been designed for the following features (Laurich and Günner, 2003):

- nitrogen removal via nitrite instead of nitrite as far as possible,
- denitrification of the sludge liquor in the pre-denitrification zone of the aeration tanks in the main flow (so that no external carbon source is needed),
- no dosage of external alkalinity for pH-regulation (using the self-regulation of the nitrification process).

Construction of the full-scale installation

Based on the results obtained in the semi-technical tests carried out in 1999, the installation has been designed for a performance of nitrification of 1,600 kg N_{ox}/d. In order to have the existing storage basin equipped for the SAT process, the following components had to be installed:

- the aeration system (consisting of blower, compressed-air lines and aeration devices),
- a discharge system for sludge retention in continuous operation,
- a discharge system for sludge retention when the basin is being emptied,
- the measuring facilities (temperature, pH, O_2) and O_2 control.

First experience in operation

After the first three months of operation the SAT installation matched all expectations. Although the volume available for treatment has slightly decreased owing to the higher freeboard level, at 1,800 kg N/d the actual performance of the installation exceeded the design value (see also Figure 2). It has been possible to get the ammonium-N concentration reduced from approximately 1,200 to 1,600 mg/l in influent to approximately

Figure 1 SAT installation under construction (left) and in operation

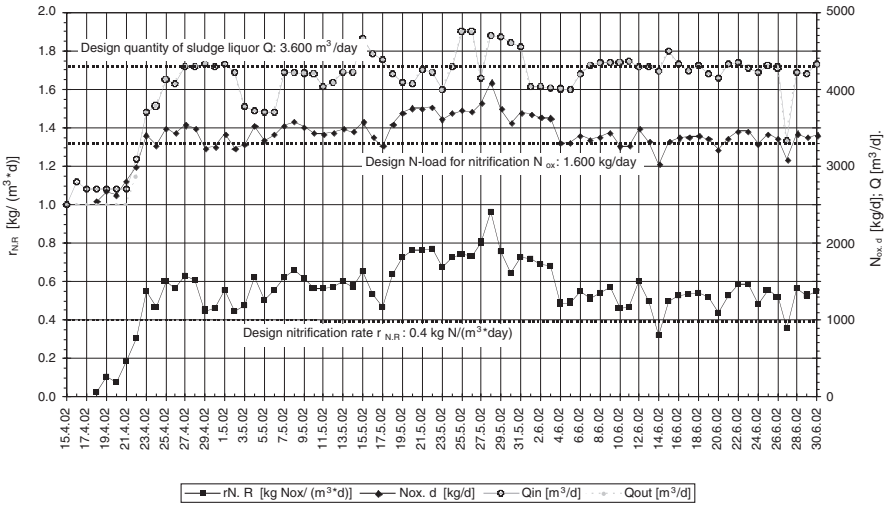

Figure 2 Performance of the SAT installation in spring 2002

800–1,000 mg/l NH_4-N in the effluent. The nitrite-N concentration in the discharge was approximately 300–600 mg/l, and the nitrate-N concentration 100–200 mg/l.

The nitrite arisen in the SAT plant was almost completely denitrified in the main distribution channel of the Dradenau WWTP. No disturbances have been noted in the main flow aeration as a result of the high nitrite concentrations of the pre-treated sludge liquor. Possibly remaining nitrite is either denitrified or further oxidized to nitrate, latest in the aeration tanks.

Pre-treatment of the sludge liquor led to a marked reduction of the main flow ammonium load so that the size of the nitrification zones could be reduced to the benefit of an improved denitrification. In combination with further operational measures (including optimisation of the BOD-influent load to the Dradenau WWTP as second biological stage and a slight increase of the ammonia control values for aeration (Ladiges and Bertram, 2004)), this resulted in a significant drop in the mean N_{inorg} discharge concentration by approximately 3.5 mg/l (see Figure 3), together with an aeration energy saving of approximately

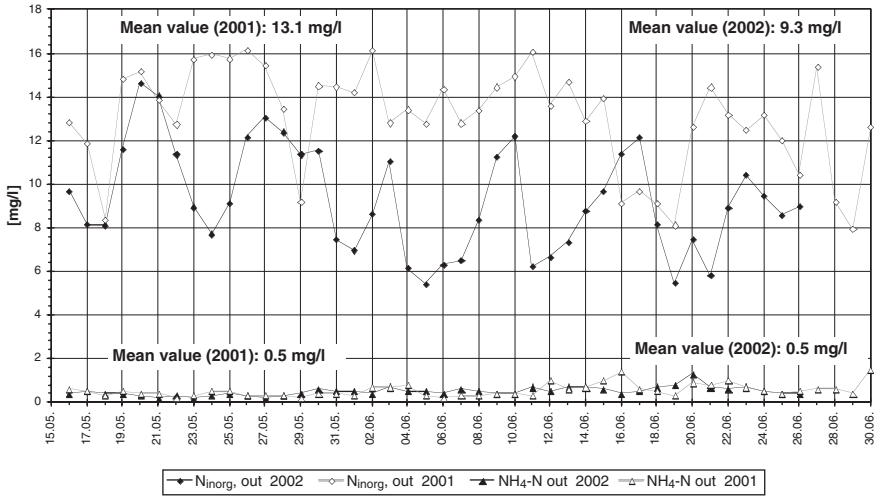

Figure 3 Comparison of the N_{inorg} effluent concentrations at the Dradenau WWTP in 2001 (without SAT) and in 2002 (with SAT), in each case for the time period from May 15 until June 30

12,000 kWh/d on the average – in each case compared with the previous year's time period and under otherwise equal conditions.

Economic efficiency analysis

One goal for the development of the SAT process was to realize an additional partial-flow treatment of the sludge liquor in a more cost-effective way. In fact, the pre-treatment costs involved at Hamburg's CWWTPs are very low and can be made up for in full by savings in the main flow of the WWTP. Savings result from a reduced oxygen demand in the aeration tanks for the nitrogen load, which has already been oxidized during the SAT treatment, and from an increase in denitrification (100% input of the nitrified sludge liquor into the anoxic zone, enlargement of the anoxic zones owing to a reduced ammonium load).

Conclusions

The *Store and Treat* process favours a cost-effective relief of waste water treatment plants owing to the specific combination of quantity management and biological treatment for ammonium-rich sludge liquors. The procedural concept is flexible and can therefore be adapted to suit different requirements. Where needed, further treatment phases can basically be added to the installation subsequently.

The full-scale application of the process at the Hamburg's Combined WWTPs has stood all tests to date. As a result, a reduction of both nitrogen effluent load and energy demand has been achieved.

References

Ladiges, G. and Bertram, N.-P. (2004). Optimisation of Hamburg's wastewater treatment plants – Three Years of Experience with the New Concept. *Wat. Sci. Tech.*, **50**(7), 45–48 (this issue).

Laurich, F. and Günner, C. (2003). The Store and Treat process for sludge liquor management. *Wat. Sci. Tech.*, **47**(12), 269–275.