Intermittent Control System Based on NH_4 + NO_3 + O_2

Maximum operational reliability and degradation efficiency are assured in Rhede (NRW, Germany) by a combination of a nitrate probe and an ammonium electrode. Together they regulate nitrogen elimination in the intermittently aerated B stage of an A-B plant. The sewage treatment plant has to deal with industrial wastewater, and therefore has a high-load. A stage, after which reliable monitoring of this relevant nitrogen parameter is required. Consistently low outflow values can only be achieved through the use of both process measurement instruments together.

Maximum operational reliability through NH_4 and NO_3 measurement instruments Rhede sewage treatment plant

Operations Manager Ulrich Dellmann would be satisfied with a single stage sewage treatment plant if it only had to handle a mixture of municipal wastewater from the roughly 20,000 inhabitants and the various small and medium-sized companies. However, industrial wastewater from the textile sector sometimes adds an additional daily COD load of 1,500 kg (consisting mainly of poorly degradable compounds). The plant's capacity is therefore 40,000 PE. This challenge can only be mastered using an upstream high-load first stage, to which this additional load is channelled through a pressure main and an equalising tank. This treatment method is known as the A-B method.

A-B method

"Another two-stage method is the A-B method. This adsorption-aeration method was developed and used by Böhnke from 1977. It consists of a high-load first stage and a normal-load second treatment stage. Both stages are strictly separated from each other, so that different biocenoses can develop. The sludge cycles are therefore also independent of each other, and the recycled sludge remains in its own stage." Source: Klärschlammforum.de

The "normal" (municipal) sewage plant inflow is channelled into both stages through a splitter. The intermittently aerated B stage, in particular, benefits from the inflow of readily biodegradable carbon compounds, without which denitrification could not occur in the non-aerated stages. Operations Manager Ulrich Dellmann knows that things could go wrong when acceptable nitrogen degradation rates have to be achieved without the help of reliable continuous measured values. Important switching points, which are now consistently realised in the aeration control system (*Fig. 1*), were determined during this period. At that time, the NO_3 and NH_4 values in the aeration tank did not always remain below 6 and 2.8 mg/l.

1. Time-based control: 30 minutes on / 90 minutes off

2. Ammonium-based control: From 2.8 mg/l

3. Nitrate-based control: From 6 mg/l

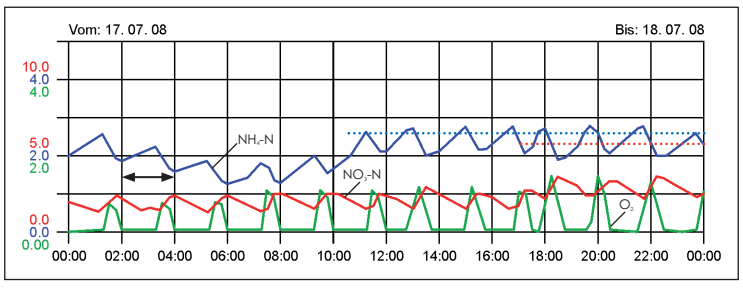

Fig. 1: Perfect combination of time-based control and a concentration-related control system that intervenes when the concentration of NH_4 or NO_3 reaches a given level.

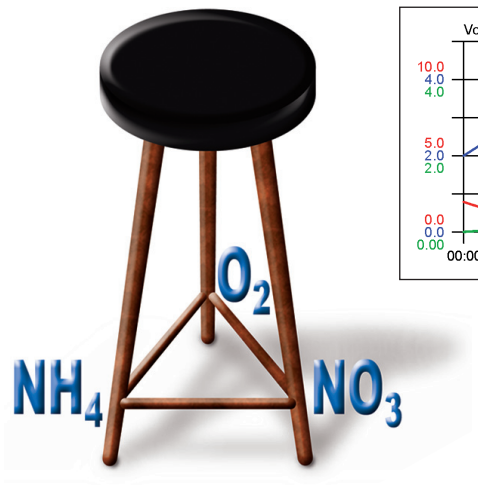

Fig. 2: As stable as a bar stool – intermittent control system based on NH_4, NO_3 and O_2.

All good things come in threes

The aeration in the low-load B stage is monitored and actuated at three levels simultaneously (*Fig. 1*). Depending on the actual ammonium and nitrate concentrations, the control systém decides whether one of these two parameters should serve as the basis for the aeration times or whether time-based control will suffice. These three balanced factors ensure maximum operational reliability (*Fig. 2*).

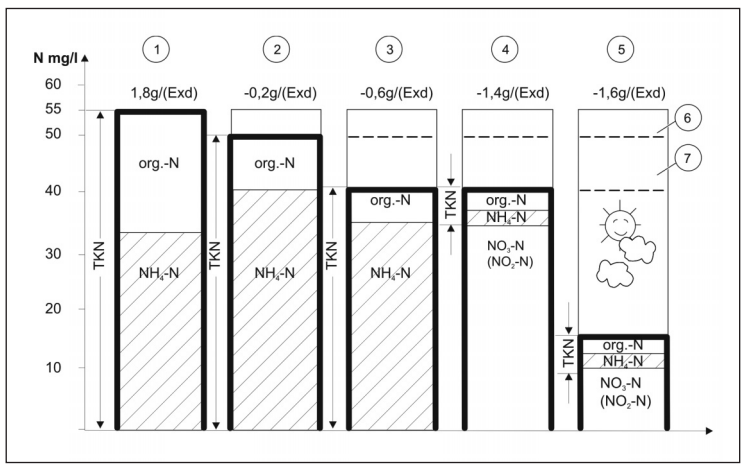

Fig. 3: Nitrogen balance in wastewater
1 Raw wastewater
2 Mechanical cleaning
3 Biological, only carbon degradation
4 Biological, with nitrification
5 Biological, with denitrification
6 Primary sludge
7 Excess sludge
/ExD = per inhabitant per day

The adjustable time specifications provide for an aeration period of 30 minutes and a non-aerated phase of 90 minutes. If, during the 90-minute pause in the aeration, the ammonium concentration reaches 2.8 mg/l, the aeration is immediately switched on, only to be switched off again when the NH_4-N concentration falls below 1.8 mg/l. In this way, explains Operations Manager Ulrich Dellmann, nitrification is carried in small packets, without additional energy consumption. The aeration is also switched off if the nitrate concentration is 6 mg/l or higher, irrespective of the ammonium concentration. So far, however, this situation has not arisen.

N_{inorg} = NITRATAX sc + NH4D sc

Nitrogen degradation is aimed at minimising the inorganic nitrogen concentration N_{inorg}, which is of relevance for wastewater charges (*Fig. 3*). At the sewage treatment plant in Rhede, a value of 2.6 mg/l N in the outflow represents an excellent result. The NITRATAX sc + NH4D sc sensors provide continuous information about the two nitrogen parameters (NO_3 + NH_4). This up-to-the-minute data helps to

- reduce monitored values,
- save wastewater changes,
- achieve compliance with limit values, and
- save energy without compromising the high level of operational reliability.

Fig. 4: Deputy Operations Manager Bernd Schüling shows us, with just a few actions, how…

Fig. 5: …uncomplicatedly and quickly process probes can be cleaned.

Probe technology for ammonium and nitrate measurement

Process measurement instruments

NITRATAX sc nitrate process probe

Stainless steel process probe for direct sample-free determination of nitrate and nitrite content in the medium (water, wastewater or activated sludge). UV absorption measurement, reagent-free. Evaluation and operation via SC 100 or SC 1000 controller. For mounting on tank edge, tank edge fastening LZX414.00.10000 is needed.

Fig. 7: NITRATAX sc nitrate process probe

Measuring range (NO_2+$_3$-N): 0.1–20 mg/l

Dimensions: 323 × 75 mm (L × D)

NH_4D SC ISE ammonium probe

Economically priced ammonium process probe made of stainless steel and PVDF (Ryton) for continuous direct determination of the ammonium concentration in the medium. Ion-selective electrode (ISE) with automatic potassium compensation. The enclosed cartridge design keeps the patented CARTRICAL® reference system separate from the surrounding medium, so that the electrode cannot be poisoned. Evaluation and operation via SC 100 or SC 1000 controller.

Fig. 8: NH4D SC ISE ammonium probe

Measuring range: 0.2–1000 mg/l NH_4-N

Dimensions: 350 × 44 mm (L × D)

SC 100 Controller

Universal controller for wall, in-pipe or control-panel mounting. Two digital sensors can be connected via splashproof connectors. Two analogue power outputs, three potential-free changeover switches (5 A 115/230 V AC, 5 A 30 V DC), digital interface for bus connection (ModBus, ProfiBus, LonBus).

Fig. 9: SC 100 Controller

LITERATURE

HACH LANGE Practice Report "Die richtige Prozess-Messtechnik für den N- und P-Abbau", February 2008

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