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Let's Solve Water

Tech note

Transparency in the biological process

DUE TO MODERN ONLINE MEASURING TECHNIQUE OF NITROGEN PARAMETERS

Since the mid-sixties there have been biological waste water treatment plants – but never have the core processes of the biological cleaning process been as transparent as today.
This is due to the fact that ammonium and nitrate, the nitrogen parameters involved in these processes, can nowadays be measured easily and economically. Unfortunately, the possibility to regulate and control connected with this is still rarely used. Even small waste water treatment plants can clearly benefit from it, which by now has been proven by many examples.

While many important waste water treatment parameters such as the pH value, ORP or turbidity could always be measured online relatively easy, this has become feasible for the nitrogen parameters ammonium and nitrate in the last few years only. Who doesn't remember those large systems of pumps, filtration unit and analyzers the mere bulk of which required extra housings? But this was not all:
these measuring and regulating systems struggled with time-delayed measurement and all sorts of errors affecting the measurement quality. Besides, the investment costs and follow-up costs were so high that only large waste water treatment plants used such measuring systems.
The ISE technology available today determines nitrogen parameters easily and reliably. ISE technology is not really new – it is a common application in laboratories. Measuring directly in the waste water, however, is new and was only enabled by some technical improvements. New, special membranes had to be developed that fulfill these special requirements. What's more, these sensors are dynamically compensated so that even heavily fluctuating concentrations of other ions cannot affect measurement. Nowadays there are even sensors that can measure ammonium and nitrate with one single sensor. Measurement itself is by now easier than pH measurement because the best systems don't even have to be calibrated against standard solutions. Only a so-called "matrix adjustment" against a photometric measurement is required to take the special matrix of the waste water into account. At a waste water treatment plant this measurement is a routine procedure and has to be done anyway. The investment and follow-up costs are so low that these measurements are also possible for medium-sized and small waste water treatment plants. Even compared to modern on site analyzers the costs are only 25–30% for one parameter; the comparison is even better if two parameters, i.e. ammonium and nitrate are considered. Ideal prerequisites then to record the processes and to act accordingly.
As described in the DWA*) regulations (DWA-A 268):
"In order to minimize energy consumption and not to affect denitrification, the selected O_2 concentration should achieve an extensive and stable nitrification, the consumed power being as low as possible."
This is always possible if, in addition to the determination of the O_2 concentration (existing in most cases), ammonium or/and nitrate are also measured online and the O_2 concentration and possibly other control variables as well are adjusted accordingly.
The summary of DWA-A 268 quotes the following among other things:
"At medium-sized and large plants, the oxygen control can be supplemented by a measurement of NH_4-N whose output signal is used to determine the nominal O_2 value or directly. If the target is to minimize the total nitrogen concentration, it is possible to design the control circuit based on the sum of the measured concentrations of NH_4-N and NO_3-N (7.3.7)".
Profitability has to be checked always, of course. By now it has been proven even for smaller plants. For the profitability accounting, the lower energy consumption due to lower O_2 concentration and the thus caused better outlet values resulting in less waste water charges has to be taken into account.

1*) DWA (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall): German association for water management, waste water and waste

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This simple, direct and economic measurement of the relevant parameters makes the substitute control strategy often implemented for reasons of economy – the measurement of indirectly involved parameters such as ORP, O2 and pH value – more unprofi table because this normally requires the additional check or measurement of the "real" parameters.

See also DWA-A 268:
"As a basic principle, the information content of an indirect measurement is lower than that of a direct measurement. From this it follows that a control system based on substitute parameters has to be designed with a greater "safety clearance". The determination of substitute parameters for the control or regulation of nitrogen elimination only makes sense if the costs of measuring the substitute parameter including the operating costs are considerably lower than that of measuring the concentration of ammonium or the oxidized nitrogen compounds. Besides, the suitability of the measuring procedure has to be checked for the existing and possibly changing conditions beforehand." […]
"The success of the strategies based on substitute parameters has to be regularly checked by measuring the ammonium and nitrate nitrogen. If necessary, this data also has to be used to adjust the control system in the case of deviations from the required outlet values."
Here the motto can only be: "Better direct than indirect".
The costs should be irrelevant because, as mentioned above, they have been dramatically reduced. What is the reason, however, that despite rising energy costs and rising sludge disposal costs, despite problems such as big fluctuations concerning the hydraulic system, contamination and matrix or too few personnel, still too few processes are controlled directly?
The new ISE measuring technique itself should not be the cause: several years of experience at a great number of installations prove that this measuring technique is not only easy to handle but also very reliable and lowmaintenance.
When considering the addition of a nitrogen measurement economically, the question of the costs of an additionally required control system and the implementation of the new control strategy comes up.
Sometimes this question can be answered easily:
if the ammonium or nitrate value is merely used to determine a new nominal O2 value this can in most cases be done very easily and at low cost. The control strategy and thus the "controller" itself are retained – the only thing that is changed is the nominal oxygen value at the controller input.
This oxygen value is now variable depending on the nitrogen parameters.
This simple strategy already achieves clear improvements – and in many cases this can be checked during the test period as many controllers allow manually changing the nominal value in dependency of the ammonium or nitrate concentration so that during the first phase the regulation can be simulated by manual adjustments.
The outlet values must of course be monitored to ensure the outlet values. Which ammonium or nitrate value leads to which nominal value for oxygen has to be determined by the operator of the plant or the person responsible for the process. Here, plant-specific factors have to be checked and evaluated by the operator that cannot be determined in general.
Practical experience shows – the correct values should be approximated with a sufficient safety clearance.
In very simple cases it may be sufficient to adjust the nominal value in 2 to 3 steps.

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Simultaneous nitrification/denitrification

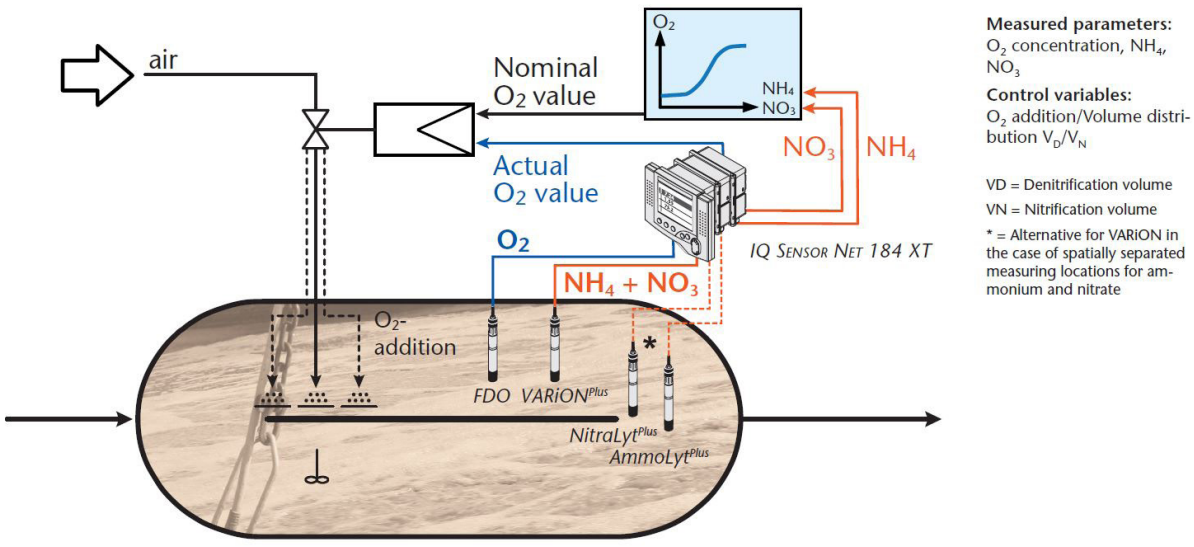

Figure 1: Simultaneous nitrification/denitrification

Summary
New technologies provide new possibilities –
besides, waste water treatment personnel nowadays has a clearly better knowledge of the biological processes of their plant than only ten years ago.
This enables even operators of smaller waste water treatment plants to use their initiative in order to find and make use of new savings potentials.

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