



Degrees of degradation take centre stage - Spotlight on nitrogen (TN_b)

Introduction

"Degrees of degradation take centre stage". This is the headline of the "Leistungsvergleich 2001" [performance comparison 2001] produced by the ATV-DVWK. For the first time the degrees of degradation for COD, phosphorus and total nitrogen (TN_b) are jointly evaluated for the whole of Germany. The degree of degradation (comparison of inflow and outflow) can be used to assess the efficiency of a sewage treatment plant. The degradation values calculated on the basis of COD and phosphorus content amount to around 90%! In contrast, the degradation values calculated on the basis of TN_b only amount to around

75% [1]. According to the ATV-DVWK, approximate TN_b values are often calculated on the basis of NH₄-N in the absence of measured values of TN_b from plant inflows. The degree of degradation for nitrogen can be determined better and more exactly by measuring TN_b directly. Apart from participation in a comparison of plant performance, operators need to know how efficient their plants are as a basis for control and planning. One of the requirements of the EU directive of 1991 concerning urban wastewater treatment also concerns to the degree of degradation.

>> DEGREES OF DEGRADATION Spotlight on nitrogen (TN_b)

Weighted degree of degradation in the regional associations									
		Degree of degrad.				Degree of degradation in %			
		Size class 1-5		Evaluated plants		Total phosphorus		Total nitrogen	
ATV-DVWK regional association	Evaluated plants	BOD ₅	COD	Number	Participation %	Size class 4	Size class 5	Size class 4	Size class 5
Baden-Württemberg	233	-	93	220	67	86	94	73	77
Bavaria	1.472	98	93	385	100	87	91	74	65
Hesse/Rhineland-Palatinate/Saarland	1.332	96	93	324	92	83	93	71	72
North	398	98	94	226	100	94	94	88	75
North-East	210	99	95	122	63	92	96	88	80
Saxony/Thuringia	332	96	91	124	99	82	92	75	63
Total ATV-DVWK	3.977	97,4	93	1.401		87,3	93,3	78,2	72,0

Table 1: Weighted degrees of degradation of sewage treatment plants in Germany and in the ATV-DVWK regional associations (Source: KA Abwasser, No. 12/2002)

Requirements of the EU directive

The EU directive concerning urban wastewater treatment requires all Member States to provide the same levels of treatment. As shown in Tab. 2, a choice can be made between a specified concentration for the outflows of sewage treatment plants and a percentage minimum reduction (= degree of degradation/efficiency). Additional requirements are specified for P and N in sensitive areas. All plants from size class 4 are affected. The directive specifies that all values must be analysed from a 24-hour mixed sample.

What requirements apply in Germany?

The relevant monitoring values are listed in Annex 1 of the German Abwasserordnung [wastewater ordinance] [3]. In contrast to the EU requirement, in Germany the monitoring values are determined from a 2-hour sample or a qualified mixed sample. Faced with a threat of legal proceedings by the EU, in 2002 the 5th amendment imposed a stricter requirement for nitrogen in the outflow of plants belonging to size class 5, reducing the limit

Parameter	Conc.	Minimum reduction [%]
Biochemical oxygen demand (BOD ₅)	25 mg/l O ₂	70-90 in conformity with Art. 4 (2)
Chemical oxygen demand (COD)	125 mg/l	75
Suspended solids, total	35 mg/l 35 in conformity with Art. 4 (2) (more than 10,000 p.e.) 60 in conformity with Art. 4 (2) (2,000-10,000 p.e.)	90 90 in conformity with Art. 4 (2) (more than 10,000 p.e.) 70 in conformity with Art. 4 (2) (2,000-10,000 p.e.)
Phosphorus, total	2 mg/l P (10,000-100,000 p.e.) 1 mg/l P (> 100,000 p.e.)	80
Nitrogen, total	15 mg/l N (10,000-100,000 p.e.) 10 mg/l N (> 100,000 p.e.)	70-80

Table 2: Requirements under the EU directive [2]

from 18 mg/l to 13 mg/l N_{tot} (= inorganic nitrogen).

If compliance with this value cannot be achieved, the reduction in the nitro-

>> DEGREES OF DEGRADATION Spotlight on nitrogen (TN_b)

Samples per size class of the sewage treatment plant	COD mg/l	BOD ₅ mg/l	NH ₄ -N mg/l	N _{tot} mg/l	P _{tot} mg/l
Size class 1 < 60 kg/d BOD ₅ , (raw)	150	40	-	-	-
Size class 2 60-300 kg/d BOD ₅ , (raw)	110	25	-	-	-
Size class 3 > 300-600 kg/d BOD ₅ , (raw)	90	20	10	-	-
Size class 4 > 600-6,000 kg/d BOD ₅ , (roh)	90	20	10	18	2
Size class 5 > 6,000 kg/d BOD ₅ , (raw)	75	15	10	13	1

Table 3: Minimum requirements in Germany

gen load can be demonstrated via the 70% ruling. This degree of degradation is calculated from measurements of the TN_b from 24-hour mixed samples from the inflow and outflow.

Which nitrogen parameter must be measured?

The German wastewater ordinance specifies monitoring values for BOD₅, COD, phosphorus, ammonium, nitrite and nitrate in the outflow of sewage treatment plants. The individual nitrogen parameters cannot be replaced by a TN_b measurement (LATON), as in Germany N_{tot} is understood as only inorganic nitrogen (= sum of NH₄-N, NO₂-N and NO₃-N) and in any case ammonium has to be determined individually (as NH₄-N) as it is a separate monitoring value.

The parameters that have to be measured in the inflow are defined in the German self-monitoring ordinance. If the 70% ruling is applied, the TN_b value must also be determined for nitrogen in the inflow and outflow. The above-mentioned improvement in the data quality in the ATV-DVWK annual comparison is achieved when the TN_b is determined directly instead of from NH₄-N via conversion factors.

Where and how is the sample taken and prepared?

To avoid any inhomogeneities due to solids, the inflow sample should be taken after the water has passed through the screen and the grit chamber

and the outflow sample should be taken after the water has passed through the final treatment unit. The 24-hour mixed samples can be taken continuously and discontinuously. In the case of inflow samples in particular, correct sample preparation and homogenization is a prerequisite for obtaining correct results. All work steps for preparing a sample that is suitable for measurement are described in DIN 38402 Part 30 (1998).

COD, TOC, TN_b and P are determined from non-settled, homogenized samples, while NH₄-N, NO₂-N, NO₃-N are determined from filtered samples. The original sample must be stirred to keep it homogeneous while partial samples are being taken [4].

Number of measurements

A program of measurements should always take account of all load situations. In order to keep the costs at a reasonable level, however, it has been proposed that, in conformity with the EU directive, around 24 samples should be analysed [4]. The sampling period should correspond to the licence under the water regulations (e.g. summer half-year).

What other parameters are of interest in the context of nutrient elimination?

Organic acids

High organic acid concentrations have a positive effect on denitrification [5].

Acid capacity

The acid capacity is of great importance for optimizing nitrification, as nitrifying bacteria produce acid, which has a negative effect on N and C breakdown [6]. These parameters can be measured just as conveniently as the degree of degradation with the TIM AQUA compact titrator and cuvette tests (Table 4).

>> DEGREES OF DEGRADATION Spotlight on nitrosen (TN_b)


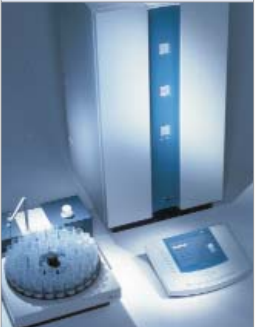



What solutions does LANGE supply for measuring the degree of degradation?

Parameter	Laboratory analysis	Process analysis
Sampling	e.g. BÜHLER 4010	e.g. Measuring station with integrated transducer
Ammonium	Cuvette tests (MR 0.015-130 mg/l NH ₄ -N)	AMTAX <i>compact</i> or <i>inter2</i> analyser
Nitrite	Cuvette tests (MR 0.0015-6 mg/l NO ₂ -N)	
Nitrate	Cuvette tests (MR 0.23-35 mg/l NO ₃ -N)	NITRATAX <i>plus</i> , <i>clear</i> or <i>eco</i> sensor
Total nitrogen (TN _b)	GANIMEDE <i>N</i> automatic laboratory analyser Cuvette tests (MR 1-100 mg/l)	
Phosphate/Phosphorus	GANIMEDE <i>P</i> automatic laboratory analyser Cuvette tests (MR 0.01-30 mg/l PO ₄ -P)	PHOSPHAX <i>compact</i> , <i>inter2</i> or <i>sigma</i> analyser
COD, Organic carbon	Cuvette tests für CSB (MB 5-60,000 mg/l) Cuvette tests für TOC (MB 2-735 mg/l)	UVAS sensor TOCTAX, astroTOC UV, astroTOC HT analyser

Table 4: LANGE water analysis products (MR = various measuring ranges)

Literature

- [1] „Abbaugrade rücken in den Vordergrund“ 14. ATV-DVWK Leistungsvergleich Kommunalen Kläranlagen 2001, Korrespondenz Abwasser, 49. Volume, No. 12, Dec. 2002, p. 1659ff.
- [2] Council Directive of 21 May 1991 concerning urban wastewater treatment
- [3] Abwasserverordnung, most recent amendment of 08.07.2002
- [4] Hinweise zum Nachweis des 70 % Frachtabbaus für Stickstoff nach AbwasserVO, KA 2/2003
- [5] Application „Organische Säuren - Bedeutung und Bestimmung“, DOC042.00.00188.Mai02
- [6] Application „Die Bedeutung der Säurekapazität auf Kläranlagen“, DOC042.00.00120.Jul00

<p>Photometers & cuvette tests</p>  <p>in the laboratory or in the field</p>	<p>Automatic laboratory analysers</p>  <p>for P and N or as FIA</p>	<p>Titration</p>  <p>for acid capacity, etc.</p>	<p>Samplers / Measuring stations</p>  <p>portable or stationary</p>	<p>Analyser</p>  <p>for P and N, etc.</p>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------