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Development of a Data Base System for Evaluating Biogas Tests

Data Management and Quantification of Methodological Effects

Results of fermentation-tests can show significant spreads due to variably applied experimental methods. In order to gather detailed data on fermentation-tests, software based on a database system was developed, which quantifies methodical differences. Hourly recorded gas yield data did not differ from gas-yields in daily recorded data. The calculated theoretical gas-yield showed a deviation of less than 10 % from semi-continuous test-results.

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Keywords

Biogas, comparability, data base

The comparability of results from biogas tests is limited if additional information on experimental setup, data processing and test conditions (e.g., fermentation temperature, duration of batch-tests) are not included in the test report. Standardised collection and processing of raw data with considering different test conditions that affect the raw data are generally required, particularly if different fermenter concepts are to be compared.

In order to centrally collect the data, which in part are logged on an hourly basis, from biogas tests with different experimental setups, a data base system was developed to collect the raw data, link them in fixed relationships and calculate standardised results considering the respective test conditions. Further evaluation of test results would then be facilitated by producing output tables.

Data base system and data standardisation

The core of the data base system is a VBA software (Visual Basic for Applications), which links the reviewed, pre-processed and imported raw data to calculate an output table (*Fig. 1*). Raw data sets were assigned to the individual fermenters with indication of date and time. The raw data were manually reviewed and verified for plausibility before importing them into the data base. Gas yields were always calculated for standard conditions. Additionally, data of digester feeding and chemical analyses were included into the data base. In this way the supplied quantity of organic matter supplied to the fermenters within a specific period of investigation could be computed cumulatively. After defining the start and end time of investigation for a specific digester, the software produces an output table on an hourly basis which can then be used for further evaluation.

Because the measuring interval of the gas analysis was adjusted to the maximum load of the sensors and the gas volumes produced from fermenters of different size, average hourly values of methane content had to be calculated from the available measurements. *Figure 2* shows a corresponding output of the data base software for a semi-continuously fed digester under steady-state conditions over a period of 28 days. Each feeding event is well recognizable.

Digesters and measurement setup

In the following, the application of the database-system is exemplified by selected test results from 36 L-digesters (filling volume 28 L, 38°C fermentation temperature, slowly moving agitator). Six digesters were operated semi-continuously: three digesters fed with base-substrate of constant quality as reference runs and three digesters fed with base-substrate and grass silage as the test runs. Feeding of the digesters took place once per day on six days a week. The hydraulic retention time was 32.7 days. Addi-

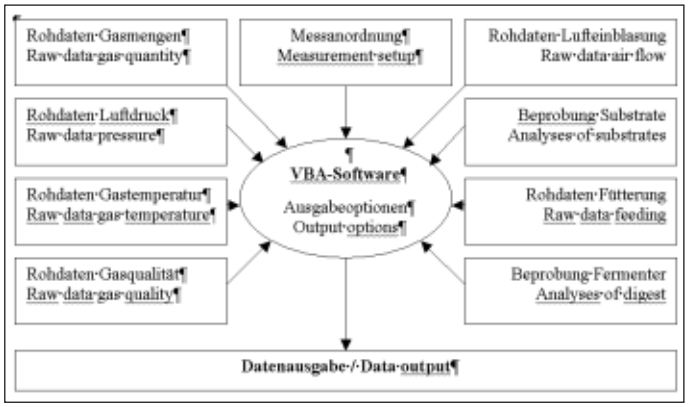

Fig. 1: Overview of the database

tionally, three digesters of identical design were available for batch tests. The volume of the produced biogas from a single digester was measured with a MilliGascounter® (Ritter, Germany) and logged hourly. Gas analyses (CH_4, CO_2, O_2, H_2, H_2S) were carried out with an automatic biogas analyser (Awite, Germany). Biogas quality was analysed automatically after 4 L gas production, respectively.

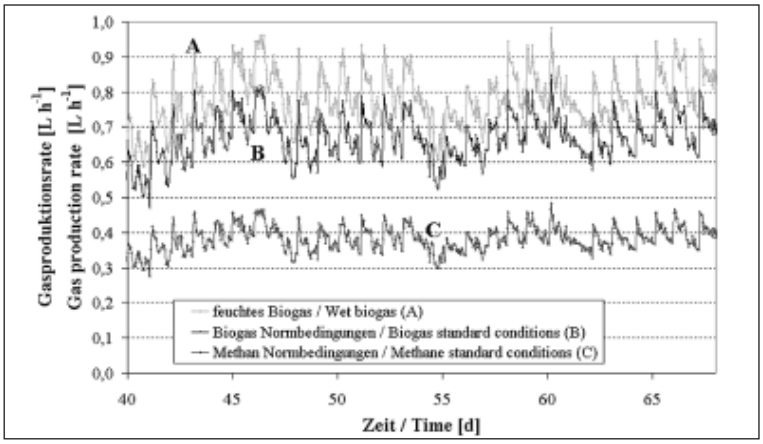

Fig. 2: Wet biogas production (A), standardized biogas production rate (B) and standardised methane production rate (C)

Selected results using different methodologies

During the experiment with grass silage as test-substrate gas amounts and qualities were manually recorded on a daily basis, parallel to the automatic hourly recordings. Raw biogas volume as well as the volumes of biogas and methane under standard conditions were then calculated from these data for comparison. The results are compiled in *Table 1*.

Assuming the absence of synergistic effects [1], a biogas yield of 266±19,6 L_N (kg VS)$^{-1}$ was determined for the grass silage tested. The theoretical gas-yield [2, 3] on the basis of chemical analyses calculates to 291 L_N(kg VS)$^{-1}$ which is slightly higher than the experimental result. A difference of less than 10 % could also be observed for the other tested substrates.

Reference runs with base-substrate only were used for the comparing batch and semi-continuous systems (*Table 2*), so that the comparison could be made without being subject to additional variations in feeding and possible synergistic effects. The presented values show no significant difference between the gas-yields when comparing batch-tests with semi-continuously operated digesters.

If pH-values measured directly after sampling are compared with values determined later in the laboratory, the laboratory values are typically higher. The database records both pH-measurements separately to facilitate comparison. The pH-values measured in the laboratory were on average 0.25 pH-units higher than those measured immediately after sampling, with a relatively large standard deviation of 0.2 (based on 259 data pairs).

Discussion of the presented results

If no parallel runs are performed, problems occurring during a test may remain unnoticed and results may be difficult to interpret. Because anaerobic digestion is a biological process that is subject to variations, an experimental approach with at least three parallel runs is recommended. Unfortunately this is rarely practicable in the case of tests in large-scale digesters. Standardisation procedures and test conditions should be reported to facilitate the comparison of test results with literature data. If the results from batch- and semi-continuous tests are compared it appears that the values are not significantly different when using a base-substrate of largely constant composition for the tests. This requires further discussion since in the case of semi-continuous tests since undigested material would be withdrawn from the digester. A lower biogas yield could therefore be expected as this material is no longer available for digestion. Possible reasons for the still identical gas yield in batch- and semi-continuous test could be the stimulation of hydrolysis and better maintenance of the sequence of microbial process in the latter case.

As pH-values are subject to change, depending on processing of samples and time delay, measurements should me made directly after sampling whenever possible.

Conclusions and perspective

The data base system is able to centrally manage raw data that are to a large part logged on an hourly basis, to standardise these data according to specified procedures, and to produce a consistent output. By means of the automatic generation of graphs, data from a particular test or a period of special interest can be rapidly visualised and evaluated further.

Because the output tables are generated specific to individual digesters, it is possible to account for the explicit experimental set-up. Future versions of the software are supposed to include additional raw data and to carry out further calculations as well as to perform automatic evaluations across several digesters.

Table 1: Comparison of means and standard deviations of specific gas yields of equal semi-continuous biogas tests with different methods of collecting the raw data in two variants ((A: base substrate + grass silage (n=3), B: base substrate only (n=3))

		specific gas yield [L•(kg VS)$^{-1}$]		Ø
data logging	**Biogas, raw**	**Biogas,stand.**	**CH_4, stand.**	**CH_4 [%]**
A hourly, automatic	305±12	261±10	148±6	56.9
daily, manual	307±11	270±10	148±6	54.6
B hourly, automatic	196±3	168±2	102±2	61.0
daily, manual	195±2	172±2	102±1	59.4

Table 2: Comparison of means and standard deviations of specific gas yields digesting base substrate in batch tests (n=6, yields after 32,7 days) and semi-continuous tests (n=9, hydraulic retention time 32,7 d)

		specific gas yield [L•(kg VS)$^{-1}$]	Ø
Kind of test	**Biogas, standardised**	**CH_4, standardised**	**CH_4 [%]**
Batch	168±21	103±13	61.6±2.2
Semi-continuous	165±16	103±9	62.6±1.3

Literature

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