Near-infrared spectroscopy for process and substrate supervision of a full-scale biogas plant

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Aim of this study was to investigate the possible use of near-infrared spectroscopy in the supervision of the biogas production process or parts thereof. It was examined, whether the surveillance of (a) the process and (b) substrate was feasible.

The following tasks were accomplished to this end: 1. Development, construction and assembly of suitable NIRS-metrology, development of proper control-software as well as of strategies for data acquisition and data handling, 2. calculation and validation of regression models on the basis of acquired spectra and reference data for (a) suitable parameters of the biogas process, (b) composition and biogas potential of the substrate, 3. calculation of continuous time series of all parameters in order to prove the possibility of continuous surveillance, 4. integrated processing of continuously calculated biogas potentials together with plant data for the prediction of the biogas production behavior of the biogas plant.

A near-infrared spectrometer was installed and equipped with NIR-measuring heads of own design and construction on a full-scale agricultural biogas plant. For 500 days spectra were continuously logged at (a) a pipe flowed through by fermenter slurry and (b) the feeding station, where silage passed. Based on regularly withdrawn reference samples and the corresponding spectra regression models were calibrated for the several constituents. Continuously logged spectra were used to calculate time series with the aid of the regression models for each constituent. Models and time series were established for the following parameters: (a) process parameters: volatile fatty acids, acetic acid, propionic acid, dry matter, volatile solids; (b) substrate parameters: dry matter, volatile solids, crude fiber, crude fat, crude protein, nitrogen-free extracts, experimentally assessed biogas potential, theoretically assessed biogas potential. Despite the partially low quality of the models it was possible to follow the course of the constituents' concentrations with good agreement.

NIRS-models, actual plant-feeding data and elementary degradation kinetics were used to calculate time-series of theoretically expectable biogas yields. Results thereof were validated against actual gas production measured at the plant. For the correlation between theoretical and actual biogas yields, coefficients of determination of up to 58% were achieved.

Based on the results of this study it is assumed that the implementation of near-infrared spectroscopy will be worthwhile in practice, if the following requirements are met:

(a) regarding process supervision: the detection accuracy proves true in further investigations,

(b) regarding substrate supervision: a certain variation in substrates and/or substrate qualities, leading to corresponding variations in the biogas yield; too homogeneous substrate qualities let supervision thereof be unnecessary.