**How well do 46 full-scale Danish anaerobic digesters at wastewater treatment plants perform?**

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Anaerobic digestion (AD) is a key technology for a sustainable future and is employed worldwide as a means to produce biogas and degrade various organic wastes. The strong emphasis on circular economy at the Danish wastewater plants (WWTP) has therefore had the consequence that many plants also include AD to treat primary and secondary sludge. Although AD has been extensively studied in lab- and pilot-scale, studies describing full-scale operation of AD at WWTPs are few. An improved understanding of how full-scale ADs are operated and how they perform is important for future optimisation of design and operation.

In this study, we conducted a six-year survey of operational data from 46 anaerobic digesters located at 22 Danish WWTPs. These data included feeding sludge flows, gas yield, and some operating parameters such as volatile fatty acids, alkalinity and ammonium. Also the microbial communities (archaea and bacteria) were analysed using 16S rRNA gene amplicon sequencing of all 400+ samples. The main objective was to learn how the Danish anaerobic digesters treating wastewater sludge are operated, and investigate whether it was possible to identify correlations between performance and microbiology.

Large differences in the general operation and performance of the ADs were recorded. However, it was unexpectedly difficult to compare the different plants since the type of chemical parameters analysed, type of analytical methods and sensors, and possibilities for accessing data, varied a lot. The survey proved that there is need for better standardisation of some chemical analyses and some equipment. The data suggested that, in most cases, thermal hydrolysis pre-treatment and thermophilic operating conditions were more efficient than mesophilic single-phase digesters, although exceptions were found. The difficulties in comparing the operation and performance of the plants made it difficult to identify correlations between performance and microbiology. However, the microbial community analysis indicated that methanogenesis occurred predominantly through the acetoclastic pathway in mesophilic digesters while the hydrogenotrophic pathway was prevalent in thermophilic. Mesophilic digesters were found to have a more diverse bacterial community than thermophilic digesters. Further research is needed to optimise methane yield and sludge degradation, which are essential parameters for achieving a good circular economy at Danish WWTPs.