Anaerobic digestion as a key technology in bio-energy production: current achievements and challenges

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Anaerobic digestion has been applied for many decades for the treatment of organic wastes like manure, wastewater sludge and crop residues. Whereas these streams were considered as a nuisance in the past, nowadays, emphasis lies on resource recovery. These wastes are, indeed, providing an important source of renewable energy. Therefore, there is a renewed interest in anaerobic digestion as a technology for sustainable renewable energy production. Also, anaerobic digestion plays a central role in a biorefinery concept. All over Europe, the application of anaerobic digestion is steadily growing, although there are major differences between individual countries on the adaptation of this technology.

Because of the high complexity of the degradation mechanisms occurring, digesters are currently still treated as black box systems, and are mainly designed by rules of thumb. Much research is carried out to gain additional insight to be used for process optimisation. Some major research topics include (i) reducing the long retention times in the digester, (ii) increasing the (limited) biogas production efficiency (currently merely ca. 50% of the organic matter in the waste stream is converted to biogas), (iii) increasing the methane content in the biogas (hereby increasing its heating value), (iv) opening the way to include lignocellulosic materials as feedstock for digestion and (v) adapting the digestion process to cope with inhibition by recalcitrant LCFA (for high lipid containing feeds) and ammonia (for high nitrogen containing feeds).

The aim of this paper is to provide an overview of the current status on anaerobic digestion research. First, an overview on the application of the technology in European countries will be provided, and it potential will be highlighted. Next, the main trends in anaerobic digestion research will be critically discussed. Highly innovative research topics in anaerobic digestion include (i) stimulation of the anaerobic micro-organisms by process technological innovations (e.g. application of microwaves and ultrasonic fields), (ii) integration of knowledge on microbial community composition and development in steering anaerobic digestion and (iii) advanced mathematical modelling for simulation and control of the digestion. Current achievements will be highlighted and future opportunities will be identified. The main aspects will be illustrated by some examples of state-of-the-art research in the respective domains.