Research Summary Sheet

Summary of Deliverable 3.4

Pre- and post-treatment of lignocellulosic material

Context and Challenges

Lignocellulosic biomass is considered as recalcitrant feedstock for anaerobic digestion (AD) due to its protective structure that limits its biological degradation. Thus, many agricultural waste types are only partly converted or are not considered for AD. Therefore, suitable pre-processing for the improvement of the performance of conventional AD remains a challenge in the development of anaerobic digestion technology.

It is aimed at investigating the pre-treatment of straw and other fibrous biomass prior to AD in order to improve the performance of conventional anaerobic digestion of recalcitrant fractions of agricultural waste, such as wheat straw. Moreover, bioethanol production from the anaerobically digested straw through the enzymatic utilization of the remaining fibre was also investigated in order to add value to the AD process through the exploitation of digestate as a bio-energy source.

The activities covered the testing and improvement of two major technologies, namely thermochemical pre-treatment and enzymatic treatment. AAU and BV operated and monitored a demonstration-scale wet explosion pre-treatment plant (AD-Booster™) at Ribe Biogas, Denmark, a full-scale biogas plant. The AD-Booster was integrated in the biogas process to perform pre- and post-treatment of lignocellulosic biomass such as straw and manure fibres. During the operation period, process parameters were tuned to maximize methane production of the biogas plant and achieve a significant conversion of lignocellulosic matter into biogas. In parallel, biomethane potential tests, bench scale digestion trials and digestate analysis were carried out at the laboratories at AAU Copenhagen.

NTUA performed lab and pilot scale experiments to test enzymatic and chemical delignification of wheat straw, followed by enzymatic hydrolysis for the production of easily biodegradable sugars. After defining the optimum conditions for the pre-treatment scheme, the anaerobic digestibility of the effluents produced was measured. Finally, the liquid effluents were fed to a pilot scale anaerobic digester, applying an increasing OLR regime.

The project leading to this application has funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 688338.

Results and Applications

The AD-Booster ™ at Ribe Biogas was brought into stable operation and delivered pre-treated materials to one out of three parallel reactors, receiving the same material but where one reactor further had pre-treatment of the material while the other two had none. Results showed stable gas productions in all reactors; however, the reactor with pre-treatment had 2.44 times higher methane production compared to the reactors without pre-treatment.

Breakthroughs, benefits and added value

If all material had been treated just over 30% more methane would have been produced at Ribe biogas from the same input raw material as a result of the tested pre-treatment process. This means far better overall economics of biogas production. At NTUA, optimum conditions for the delignification and enzymatic hydrolysis of wheat straw were defined. It was proven that the resulting liquid effluents could be fed to an anaerobic digester with satisfactory COD removal efficiencies (over 70%). Moreover, alkaline pre-treatment and enzymatic hydrolysis of straw digestate is a satisfactory approach for the valorization of digestate offering elevated saccharification yields reaching up to 76%.

Further information on NoAW project: http://noaw2020.eu

INRA (Coordinator): Prof. Nathalie Gontard, e-mail: nathalie.gontard@inra.fr

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