Research Summary Sheet

Summary of Deliverable 4.2

Innovative strategies to valorise 2 steps AD digestate towards biofuels and biochar

Context and Challenges

Public policies in China and in several EU Member States have promoted the use of anaerobic digestion to treat organic wastes and generate renewable energy. This has resulted in the production of considerable volumes of di-gestate as by-product, which could raise an environmental concern in regions with high soil nutrient levels. In this deliverable we proposed to investigate innovative routes for the valorization of the solid separated fraction of the digestate by means of bioethanol and/or pyrolysis processes. Three full-scale agricultural biogas plants have been selected. These biogas plants are located in France and Italy.

Digester # 1: The first one is working in dry process mode (GAEC Val Maury, Les Rabiers, 89110 La Ferté-Loupière),

Digester # 2: the second one in a continuous stirred tank reactor (CSTR) process (SARL Vallée de l'ISLE Energy, 24110, Saint Astier) and

Digester # 3: the third one a continuous stirred tank reactor (CSTR) process (SARL AZIENDA AGRICOLA CORTETANO, Via Trip-oli, 1, 26028 Cortetano CR, Italie)

On these different agricultural biogas plants, the solid separated fraction of the digestate have been collected and innovative valorization routes applied.

The main objectives of task 4.2 are as follows:

1. *Selection of full-scale anaerobic digestion plants and characterization of the liquid and solid digestate.*
2. *Pre-treatment and bioethanol production from the solid fraction.*
3. *Pyrolysis of the solid digestate and the solid residue from the bioethanol step.*
4. *Utilization of biochar from pyrolysis of solid digestate as soil amenders and P-solubilization enhancement using bacteria strains.*

First of all, several solid separated fractions of digestate (SS-DIG) have been collected from different agricultural biogas plants located in France and Italy. Physicochemical characterization has been done on this digestate. Then, different mechanical and/or chemical pre-treatments have been investigated on collected SS-DIG, to evaluate their impact on the enzymatic hydrolysis performances and to assess the best conditions for bioethanol pro-duction compared to raw solid digestate. In parallel, pyrolysis

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assay has been performed on the SS-DIG (pre-treated or not) to produce energy carriers (bio-oil, syngas) and biochar for agronomic uses.

Results and Applications

The main results are the following ones:

***1)** VBM (Vibro Ball Milling) appears to be a promising technology to improve sugar recovery after enzymatic hydrolysis from dry solid anaerobic digestate. VBM of dry anaerobic digestate led to a significant decrease in the particle size and crystallinity. The best results in terms of cellulose and hemicelluloses hydrolysis were noted with VBM for 30 min, with hydrolysis yields of 64% and 85% for hemicelluloses and cellulose, respectively. Bio-ethanol fermentation by simultaneous saccharification and fermentaion (SSF) under this condition led to an ethanol yield of 4.3 g eth L-1 (corresponding to 90% of the theoretical value) compared to 0.81 g eth L-1 for raw solid digestate.*

***2)** Coupling chemical treatment with ball milling appears to be efficient as combined processes to improve the digestibility of SS-DIG. The pre-treatment of SS-DIG with Ca(OH)2/ milling 60 min was effective as treatment in increasing the reducing sugar yield of SS-DIG as compared to the NaOH and KOH pre-treated SS-DIG milled for the same time. However, the produced bioethanol amount from KOH pre-treated SS-DIG milled for 60 min was (83.04 mg/g) higher than that produced from Ca(OH)2 pre-treated SS-DIG (59.36 mg/g) under the same time of milling. The main reason is the incomplete consumption of xylose during the fermentation of Ca(OH)2 pre-treated SS-DIG*

***3)** Through the pyrolysis process, SS-DIG waste had been converted to bio-oil, bio-char and syngas by pyrolysis at 500°C. Pyrolysis trials to a product distribution of 34% of bio-oil; 38% of biochar and 30% of syngas. Syngas exhibited a LHV of 12.5 MJ / m3 and bio-oil a HHV of 21.9 MJ kg-1. Agronomic trials (lixiviation tests, phosphorous solubilization, growth plants tests) are currently being carried out. In parallel, pre-treatment of SS-DIG by NaOH or ball milling was not effective and led to a reducing biochar yield. Physicochemical properties of the resulting biochars are under analysis.*

Breakthroughs, benefits and added value

Such results give significant advances on alternatives valorization routes of the solid separated fraction of the digestate from agricultural biogas plants. They will be useful to drawn preliminary energy, economic and environ-mental balances.

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

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