Mechanical pretreatments of cattle manure before anaerobic digestion

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Anaerobic Digestion (AD) represents nowadays an attractive and efficient technology to convert energy from biomass feedstocks and a interesting wastes management.

In Europe, biogas is mainly produced from anaerobic digestion using agricultural wastes, manure and energy crops. (74% in 2015)

Cattle manure is a major input to produce green energy by AD, in particular from countries in Northern and Western Europe

87Mt/an of cattle manure in France.

AD is a complex decomposition process of organic substrate by anaerobic microorganisms under oxygen-free conditions.
Manure is often mixed with crops and fibers

Recalcitrant compounds, floating layers, heterogeneous feedstocks
Several pretreatments have been developed in order to achieve a better performance on AD.
PRETREATMENTS: CHALLENGES

- A higher methane yield and rate
- A better organic accessibility
- Avoiding inhibitors formation
- Minimize energy and water demand
- Economically feasible.

Three types of pretreatments can be in general distinguished: physical (mechanical), chemical and biological and often a combination among them.

PHYSICAL PRETREATMENTS

- Easy to implement.
- Reduce solid particle size
- Used to facilitate feeding operations and mixing.
- Increase solubilisation of organic substrates
- Increase biogas production rate and biogas yields.

Evaluate biochemical and physical effects of mechanical pretreatments operation particularly *comminution* on cattle manure at lab-scale before AD.
1. Feedstocks
Cattle manure of a local livestock farm (Mont du Lyonnais, Lyon-France)

2. Pretreatments

- Fresh Cattle Manure
- Shredding (SP)
- Mixing (MP)
- Blending (BP)
3. Experimental procedure

**BMP test** (Holliger et al. 2016)
Mesophilic (35°C)
Batch assays

**Inoculum:**
Anaerobic sludge from a wastewater treatment plant (Lyon, France)
✓ Biochemical characteristics: organics compounds solubilization

✓ Physical characteristics: particle size distribution, water retention capacity

Methane yield and rate

Enhancement of physical properties

Pretreatment evaluation
### MAIN CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Untreated</th>
<th>Shredding</th>
<th>Mixing</th>
<th>Blending</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>% (total weight)</td>
<td>15.9±0.2</td>
<td>15.2±0.1</td>
<td>9.1*±0.1</td>
<td>9.8*±0.4</td>
</tr>
<tr>
<td>VS</td>
<td>% (TS)</td>
<td>78.4±0.2</td>
<td>77.3±0.1</td>
<td>77.3±0.6</td>
<td>74.0±0.4</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8.44</td>
<td>8.73</td>
<td>8.58</td>
<td>8.40</td>
</tr>
<tr>
<td>BMP</td>
<td>mL/gV</td>
<td>210±11</td>
<td>216±6</td>
<td>222±6</td>
<td>235±3</td>
</tr>
<tr>
<td>WSP**</td>
<td>%RS</td>
<td>7.5±0.6</td>
<td>12.0±0.7</td>
<td>14.1±0.7</td>
<td>20.2±1</td>
</tr>
</tbody>
</table>

*TS contents after water addition for pretreatment  **Water Soluble Phase
BMP TEST

**BMP TEST**

- Untreated
- Shredding
- Mixage
- Blending

**BLENDING PRETREATMENT**

- Increase of 11% on methane yield
- Increase of 18% on methane rate.

Increase of water-soluble contribution to BMP from 7% to 20% with pretreatment application.
COD and TKN Balance

[Bar charts showing percentage breakdown of COD and TKN for Untreated, SP, MP, and BP samples. Each bar is divided into particulate, water-soluble: other, water-soluble: VFA, and water-soluble: ammonia components.]
PARTICLE SIZE DISTRIBUTION

WATER RETENTION CAPACITY

Increase of 12% between untreated and mechanical pretreatments applied
The feedstock characterization proposed enabled to evaluate the mechanical pretreatments effects on cattle manure.

- Particulate fraction of TKN and COD was reduced with pretreatments.
- The water-soluble COD phase and methane production also increased.
- Blending pretreatment increased 11% on methane yield and 18% on methane rate regarding to untreated manure.
- Physical properties as reduction of particle size and water capacity retention were only improved with Shredding pretreatment.
PERSPECTIVES

- Evaluation at full-scale with different mechanical devices
- Rheological properties
- Energy consumption
Thank you for your attention!

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