Pre-treatment technologies for biogas production

Günther Bochmann
Composition biomass

- Proteins
- Fats
- Cellulose
- Hemicellulose
- Lignin
Four steps of AD

**Hydrolysis**
- High molecular substances
- Polymers, Monomers
- Enzymes
- $H_2S$
- $CO_2$, $H_2$
- Org. acids, alcohols

**Acidification**
- Acidification bacteria
- $CO_2$, $H_2$

**Acetogenesis**
- Acetogenic bacteria
- $CO_2$, $H_2$
- Org. acids, alcohols

**Methanogenesis**
- Methanogenic bacteria
- $CH_4$, $CO_2$, $H_2$, $CO_2$, $H_2$, $NH_3$, $H_2S$, $H_2$
- Methanogenic bacteria
- $CO_2$, $H_2$
- Org. acids, alcohols

- Acetic acid
- Acetic acid
Aims of pre-treatment technologies

Increasing reactor productivity by

- Degradation rates
- Increasing biogas yields
- Increasing process stability
- Degradation of hard degradable substances
Pre-treatment technologies

Biochemical pre-treatments
  - Microbial pre-treatments
  - Enzymatic pre-treatments

Chemical pre-treatments
  - Caustic pre-treatments
  - Acid pre-treatments

Physical pre-treatments
  - Mechanical pre-treatments
  - Thermal pre-treatments
  - Ultrasonic pre-treatments

Combined processes
  - Thermal-chemical pre-treatments
  - Thermo-mechanical pre-treatments
Pre-treatment technologies I

Microbiological pre-treatment

- 2 phase system ("Hydrolysis and methanogenesis")
- Different pH-values

Advantages/disadvantages

- \( \text{H}_2 \) and \( \text{CO}_2 \) production
- Increasing methane concentration
- Higher process stability
Applications I (Microbiological)

- Multi stage fermentation systems
Pre-treatment technologies II

Mechanical pre-treatment

- Cutting
- Milling

Advantages/disadvantages

- Electrical energy demand
- Increased biogas yield (depends on the particle size)
- Reduction of swim layers
Pre-treatment technologies III

Thermal pre-treatment

- External reactor
- Temperatures 100 – 230 °C
- Different pH-values

Advantages/disadvantages

- Process engineering/energy demand
- Increased biogas yield
- Production of bacteriostatic components
Applications II (Thermal)

- Thermal pre-treatment (e.g. TDH)
- Substrates
  - Energy Crops
  - Brewers spent grains
  - Slaughter house wastes
  - Canteen/kitchen wastes
  - Sewage sludge
Pre-treatment technologies IV

Combined technologies

- Steam-explosion
- Extruder

Advantages/disadvantages

- High thermal energy demand
- Increased biogas yield or degradation rate
- Reduction of swim layers
Applications III (Thermo-mechanical)

- Steam-explosion
- High energy demand
- Heating from 100 °C → 180 °C
  - E.g. 20 % DS → 83,55 kWh / Mg FM energy demand

- Spontaneous decompression
  - Evaporation of water
  - Destroyed cell structure
Applications IV (Thermo-mechanical)

- Extruder technology
- Electrical energy demand
- Compression $\rightarrow$ Energy conversion into heat
  - E.g. 65 kW $\rightarrow$ ~0.8 t / h
- Influence to degradation rate
  - Retention time of < 40 d $\rightarrow$ higher gas yield of ~5-15 %
  - Retention time of > 50 d $\rightarrow$ no additional gas yield was measured
### Overview

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<th>Pre-treatment technology</th>
<th>Increasing specific surface</th>
<th>Degradation lignocellulose complex</th>
<th>Influence to AD process</th>
<th>Energy demand / specific costs</th>
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Conclusions

- Advantage of pre-treatment technology depends on substrates
- Pre-treatment technology specific for chemical composition
- Effect of pre-treatment varies (positive/negative effect possible)
- Additional investment costs
- Energy balance
Thank you for your attention

Günther Bochmann

Institute of Environmental Biotechnology
Department of Agrobiotechnology IFA-Tulln
University of Natural Resources and Life Sciences Vienna
A-3430 Tulln
Konrad Lorenzstrasse 20

guenther.bochmann@boku.ac.at
http://www.ifa-tulln.ac.at

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