# Pre-treatment of feedstock for enhanced biogas production

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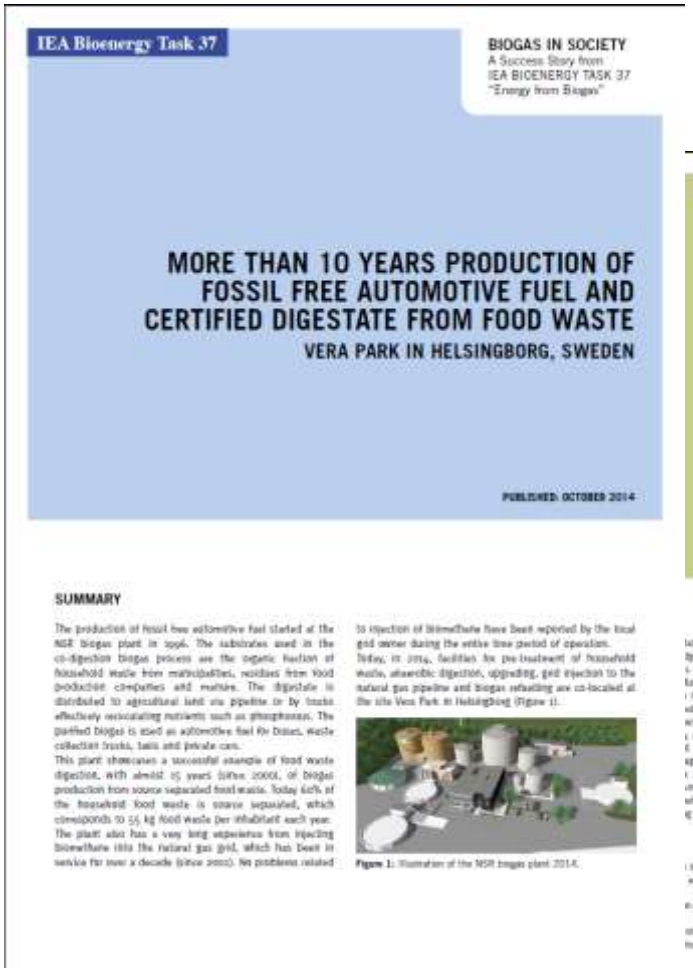
# IEA Task 37

- Work programme 2013-2015
- Work
  - Knowledge exchange
  - Technical brochures
  - Success stories
  - Studies

- Australia, Austria, Brazil, Denmark, European Commission, Finland, France, Germany, Ireland, Norway, South Korea, Sweden, Switzerland, The Netherlands, United Kingdom

www.iea-biogas.net

# Task 37


IEA Bioenergy Task 37
BIOGAS IN SOCIETY
A Success Story from
IEA BIOENERGY TASK 37
"Energy from Biogas"
MORE THAN 10 YEARS PRODUCTION OF FOSSIL FREE AUTOMOTIVE FUEL AND CERTIFIED DIGESTATE FROM FOOD WASTE
VERA PARK IN HELSINGBORG, SWEDEN
PUBLISHED: OCTOBER 2014
SUMMARY


IEA Bioenergy Task 37
BIOGAS IN SOCIETY
A Case Story from
IEA BIOENERGY TASK 37
"Energy from Biogas"
REVAQ CERTIFIED WASTEWATER TREATMENT PLANTS IN SWEDEN FOR IMPROVED QUALITY OF RECYCLED DIGESTATE NUTRIENTS
PUBLISHED: APRIL 2015
REVAQ
Renare vatten – bättre kretslopp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A Case Story from
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"Energy from Biogas"
BIO-ENERGY IN FAMILY FARMING
EW SUSTAINABLE PERSPECTIVE FOR THE RURAL SECTOR IN BRAZIL


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ry Reports Summary

# Recently published brochures

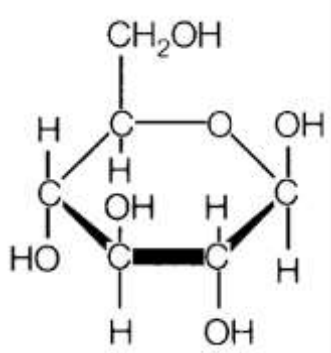
# Aim of pretreatment technologies

- Reduction of specific production costs
  - Substrate costs (%)
  - Investment costs (%)
  - Operation costs (%)

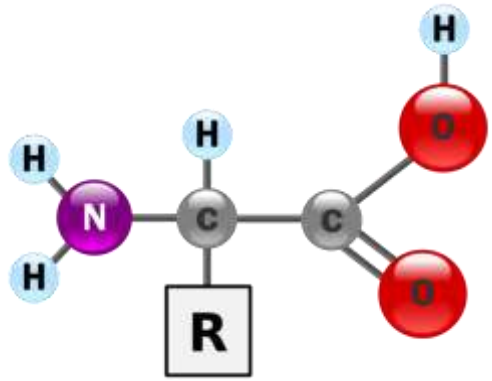
- Realisation by
    - Increasing the biogas yield
    - Inceasing degradation rate
    - Increasing the plant efficiency
    - Reduction of operation costs

# Substrates

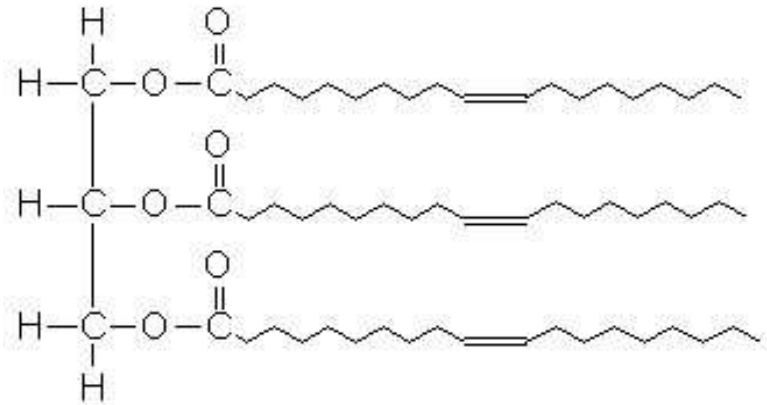
- Kohlenhydrate




- Proteine

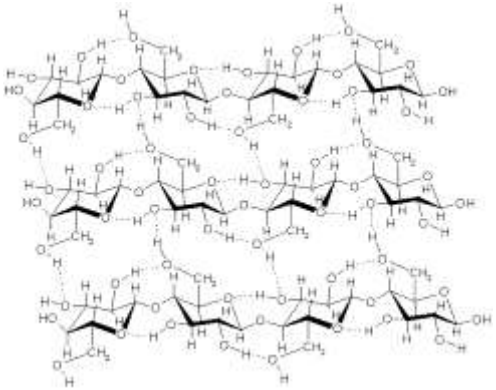


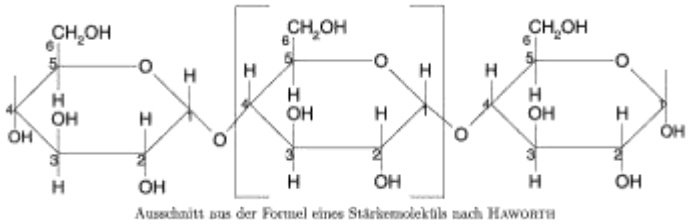

- Fette

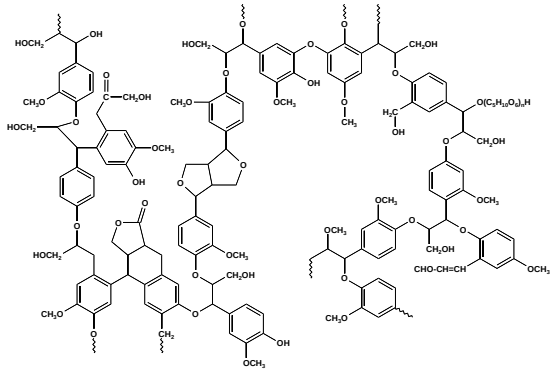


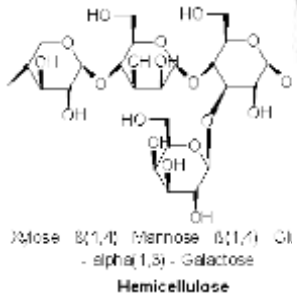
# Carbon hydrates

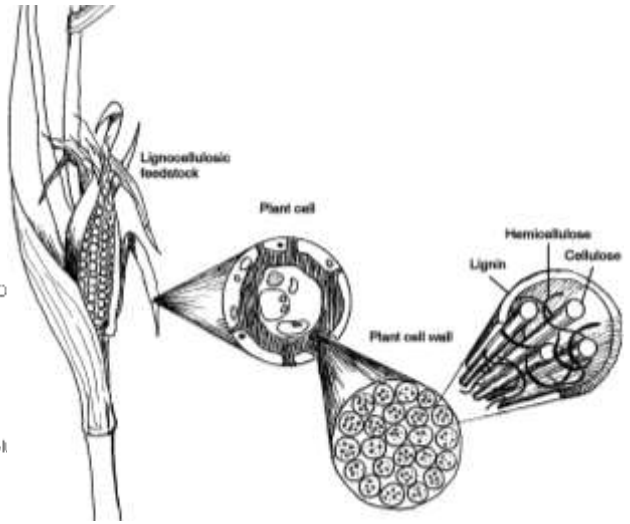
- Starch
- Cellulose
- Hemicellulose
- Lignin



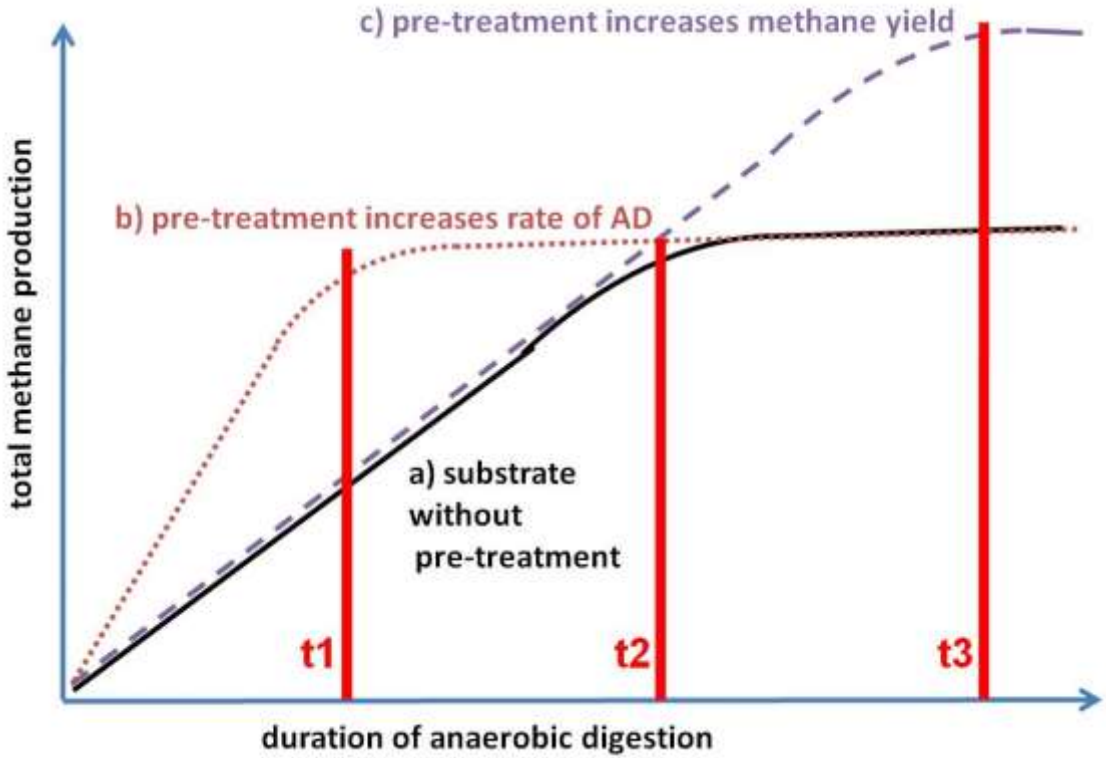




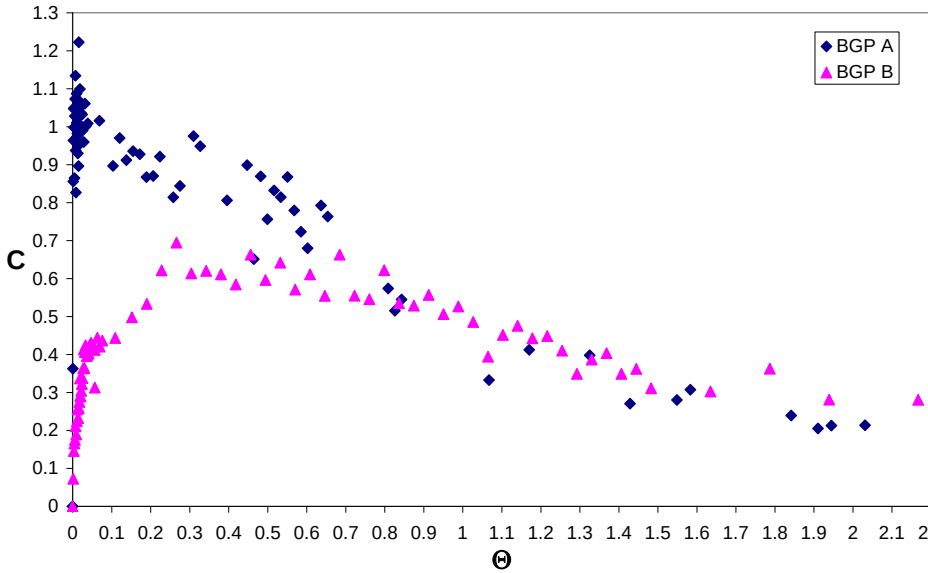



# Impact pre-treatment



# Impact pretreatment on AD

- Higher gas production can occur
- HRT
- Specific retention time in digester
- Digester system need to be included
- Viscosity
- Substrate charateristics



# Pre-treatment technologies

| | | | | |
|---|---|---|---|---|
| Physical | Mechanical | Thermal | Ultra sound | Electrocinetical Desintegration |
| Chemical | Alcaline | Acidic | | |
| Biological | Microbiological | Enzymatical | | |
| Combined processes | Steam Explosion | Extrusion | Thermo-chemical | |

# Mechanical

## Principle

Mechanical crushing

e.g. cutterbars

## Mode of action

Increasing of specific surface

Quelle: IKTS Frauenhofer

- **Advantage**
  - Relatively low invesment costs
  - Relatively low energy demand

- **Disadvantage**
  - Interfering materials reduce life time of unit significantly

# Thermal

## Principle

Thermal pretreatment leads to disintegration of hard degradable substances

## Mode of action

Solving of hemicellulose and swelling of biomass

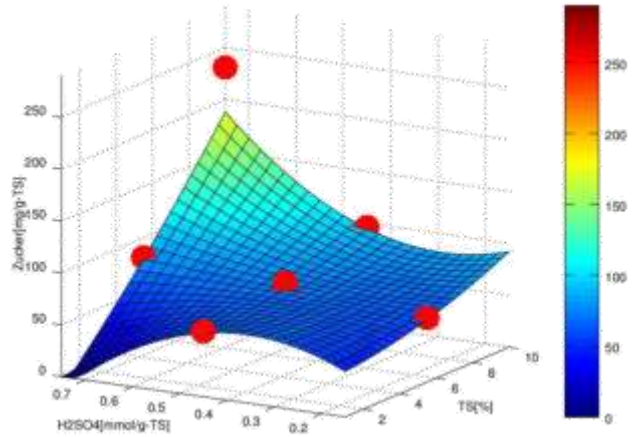
Quelle: Dr. Franke ATZ/D

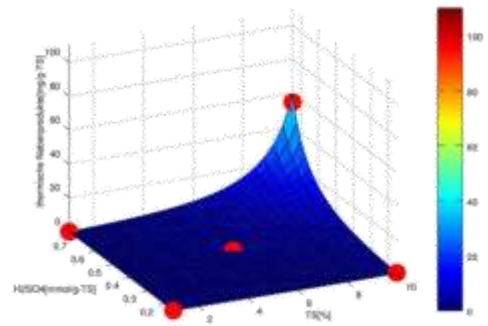
- Advantage
  - Higher gas yield
  - Exclusively heat demand

- Disadvantage
  - High investment costs
  - Production of inhibiting substances

# Thermal processes

- Non-enzymatic browning reaction
- Maillard reaction
  - 3 step process
    - End products melanoidines
- N-catalysed process
- pH-value essential for pathway
- Bacteriostatic effect of intermediate products



# Steam explosion

## Principle

Heating and abrupt decompression

## Mode of action

Rupture cell structures

Quelle: Boku

- Advantage
  - Higher gas yield
  - Only thermal energy

- Disadvantage
  - Higher investment costs
  - Formation of inhibiting substances

# Thermo-mechanical

## Principle

Extruders crush biomass

## Mode of action

Increasing of specific surface

Quelle: IFA Tulln

- Advantage
  - Degradation rate
  - Relatively low investment costs
  - Low energy demand

- Disadvantage
  - Interfering materials reduce life time of unit significantly

# Chemical

## Principle

Addition of lye or acid in an additional pre-treatment step

## Mode of action

Solving of lignocellulose complex

Quelle: enbasys

- Advantage
  - Higher gas yield
  - Faster degradation

- Disadvantage
  - Operation costs
  - Production of inhibiting products

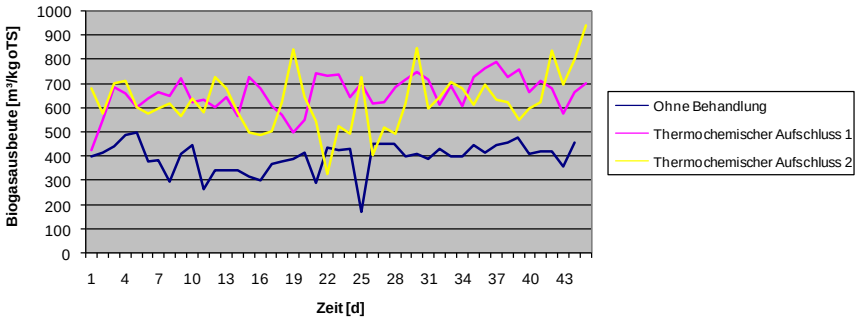
# Thermo-chemical

## Principle

Support of chemicals through heat

## Mode of action

Solving of lignocellulose complex




- **Advantage**
  - Higher gas yield
  - Faster degradation

- **Disadvantage**
  - Operation costs
  - Production of inhibiting products

# Microbiological

## Principle

Additional digester

## Mode of action

Reduced pH enables enzymes
to work in their optimum

Quelle: AAT

- Advantage
  - Faster degradation
  - Higher methane concentration

- Disadvantage
  - No higher gas yields to be expected

# Preacidification

- Or dark fermentation
  - Formation of VFA and alcohols
  - $H_2$ and $CO_2$
- pH value important
  - Increased enymatic activity
- Recirculation
  - Microbiology
  - Increasing buffer capacity
- $H_2S$ formation

# Ultra sound

## Principle

Ultra sound into digester

## Mode of action

US frequences lead to cavity or the formation of gas bubbles and their implosion

Quelle: ULTRWAVES /D

- Advantage
  - Low energy demand
  - Low investment costs

- Disadvantage
  - No direct degradation of biomass

# Electrocinetical disintegration

## Principle

Addition of high voltage impulses

Quelle: ATRES Group/D

## Mode of action

Electrical field destroyes ionic bounding of cell walls by changing the charge

- Advantage
  - Low energy demand
  - Low investment costs

- Disadvantage
  - No direct degradation of biomass

# Overview influences of the pretreatment technologies

| Pretreatment method | Cellulose decry-stallisation | Hemicellulose degradation | Lignin degradation | Increasing specific surface |
|---|---|---|---|---|
| Biological | | | | + |
| Milling | + | | | + |
| Steam explosion | | + | + | + |
| Concentrated acid | | + | + | + |
| Diluted acid | | + | | + |
| Alkali | | - | + | + |
| Extrusion | | | | + |

# Summary/conclusion

- Many tests have no reliable data
  - 2 points for BMP tests
  - Sufficient duration
- Pre-treatment technologies specific to substrate
- Pre-treatment technologies specific to plant
- Awareness of investement and operation costs
- Energy balance
- Awareness of higher gas yield
- Additional effects of pre-treatment technologies

# Thank you

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