Adaptation of plant to new substrates

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OVERVIEW

- What properties have the substrates?
- Once the fermenter for the new substrates suitable?
- Is a pre-treatment of the substrates previously necessary?
- What needs to be modified at the biogas plant?
- Composition substrates
- How can the gas yields are calculated?
- Feeding systems - solid dosage
What properties have the substrates?

If the biogas plant with other substrates be operated, so various points to check:

Origin of the substrates
- vegetable origin
- animal origin

What is the nature of the substrate?
- solid
- liquid
- pure material
- How high is the percentage of water?
- Are contaminants and interfering substances included (e.g. cores, sand, plastic, metal)?
- If the substrate contains long fibers?

What is the composition of the substrate?
- carbon hydrates
- protein
- fat
- lignine
Once the fermenter for the new substrates suitable?

- In what quantities the substrate is available?
- Is it regularly available?
- What is the **Organic Load Rate (OLR)** in the use of new substrates?
- What is the **Hydraulic Retention Time (HRT)** in the use of new substrates?
- That concentration of dry substance in the digester will be in the use of other substrates?

Are the substrates pumpable?

- Can the existing pumps transport the substrates?
- Can be mixed with the existing agitators the substrates?

- Is expected to the formation of floating and sinking layers?
- Is the formation of foam possible?

- If enough gas produced?
- Is the gas quality good?
Is a pre-treatment of the substrates previously necessary?

A pre-treatment of the substrates is required, when contaminants and interfering substances are present

- contaminants are: e.g. seeds which consist essentially of lignin and do not produce biogas

- interfering substances are: sand, stones, metal, plastic, wood

The separation of contaminants and interfering substances from the substrates is therefore necessary for trouble-free operation

Include the substrates meat (kitchen waste, waste from slaughter)?

Nature of the substrates

- Large constituents, e.g., Fibers (grass), leaves, fruit must be crushed

The substrates contain a lot of cellulose-lignin components, the degradation of the cellulose is therefore more difficult and takes longer.

- pretreatment to speed up the production of biogas is of advantage
Is a pre-treatment of the substrates previously necessary?

Lignin-cellulose compounds (e.g., straw) contain a lot of cellulose. The cellulose can not be used when the lignin interfere with the access to the enzymes. The cellulose-lignin complex must be destroyed to the extent that the enzymes can get to the cellulose.

The decomposition can be made with the following procedures:

- Heat-up
- Treatment with acid or alkali
- Mechanical crushing
- Ultrasound
Is a pre-treatment of the substrates previously necessary?

- Lignin
- Cellulose
- Hemicellulose

Cellulose:
- Crystalline
- Amorphous

Hemicellulose:
- Crystalline

Endoglucanases
- Cellulose
- Amorphous
- Crystalline

Exoglucanases
- Cellulose
- Amorphous

Cellulose:
- Elementary fibrils

Hemicellulose
- Lignin
Is a pre-treatment of the substrates previously necessary?

BioCutter

Cow dung

Hammer mill
Is a pre-treatment of the substrates previously necessary?

Disintegration with ultrasound

before

after
Is a pre-treatment of the substrates previously necessary?

Separation shredder

Raw material

Food waste with packing material

Packaging

Plastic, cans, closures

Organic material
What needs to be modified at the biogas plant?

Guideline

1. Determining the properties of the substrates
   ● Composition of the substrates
   ● Gas yields of the substrates

2. Pre-treatment of substrates
   ● Separating contaminants and interfering substances
   ● Crushing of the substrates
   ● Disintegration of the substrates

3. Intermediate storage of the substrates
   ● Preservation of substrates such as production of silage
   ● Preliminary tank for liquid substrates
   ● Storage areas for solid substrates

4. Adjustment the feeding technique for the substrates
   ● Selection of pumps for liquid substrates
   ● Selecting investments for the supply of solid substrates
What needs to be modified at the biogas plant?

5. Review and adjustment of the mixing technique in the fermenter
6. Review and adjustment of the heating of the digester
7. Sanitation or sterilization of the substrates with the use of some varieties of food waste
8. Change in operation of the digester
   ○ Slow adaptation to the new substrates
     → Alteration of the bacterial cultures in the digester, especially in the first stages of decomposition
9. Verify the new gas quality
   → Adjusting the drainage
   → Adjusting the desulfurization at higher \( \text{H}_2\text{S} \) concentrations in the gas
Substrates

Definition substrates

**Substrates**
are the raw materials from which the biogas is recovered. The substrates contain complex substances that are converted into biogas by microbial degradation (fermentation, anaerobic digestion).

**Substrates**
consist of biomass, which is non-fossil origin.
Substrates

- Substrates consist mainly of
  - carbohydrates (cellulose, starch, sugar)
  - hemicelluloses (polyoses)
  - pectins
  - proteins
  - fats

- Substrates with a high content of lignin, such as wood and coconut peel and lignincellulose, such as straw and bagasse are not suitable. Lignin can not be degraded to biogas.

- Substrates with a high content of water and are not suitable for direct combustion, eg. manure and sewage sludge can be used for the production of biogas.
Substrates

Plants → Phytomass

- Plants with a high content of carbohydrates and lower proportions of protein and fat
- Targeted cultivation for energy → energy crops

Sunflower

Grain

Maize

Sugar beet
Animals \(\rightarrow\) Zoomass

Animals transform plants into zoomass. This results in various products from which biogas can be produced.
Substrates

Zoomass
- Faeces and urine (manure) from livestock
- Activated sludge from the wastewater treatment

Cattle manure

Solid manure

Chicken manure

Sewage sludge
## Substrates

### Composition of Various Substrates (% of Dry Matter)

<table>
<thead>
<tr>
<th>Component</th>
<th>Primary sludge</th>
<th>Secondary sludge</th>
<th>Municipal Refuse</th>
<th>Meat packing waste</th>
<th>Cattle manure</th>
<th>Chicken manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile solids</td>
<td>75.0</td>
<td>70.0</td>
<td>82.1</td>
<td>92.0</td>
<td>72.0</td>
<td>76.0</td>
</tr>
<tr>
<td>Lipids</td>
<td>10.3</td>
<td>5.8</td>
<td>6.4</td>
<td>54.6</td>
<td>3.5</td>
<td>1.5</td>
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<tr>
<td>Cellulose</td>
<td>32.2</td>
<td>9.7</td>
<td>35.0</td>
<td>-</td>
<td>17.0</td>
<td>28.3</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>2.5</td>
<td>-</td>
<td>16.5</td>
<td>-</td>
<td>19.0</td>
<td>11.9</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>19.0</td>
<td>53.7</td>
<td>5.8</td>
<td>28.7</td>
<td>19.0</td>
<td>28.8</td>
</tr>
<tr>
<td>Ash</td>
<td>25.0</td>
<td>21.0</td>
<td>17.9</td>
<td>8.0</td>
<td>28.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

Pavlostathis/Giraldo-Gomez 1991
### Comparison of various substrates

<table>
<thead>
<tr>
<th>Substrates</th>
<th>Pig manure 1)</th>
<th>Cattle manure 1)</th>
<th>Chicken manure 1)</th>
<th>POME 2)</th>
<th>Sewage sludge 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>DM %</td>
<td>5,1</td>
<td>7,4</td>
<td>27,5</td>
<td>6,7</td>
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<tr>
<td>Organic dry matter</td>
<td>ODM %</td>
<td>4,1</td>
<td>5,9</td>
<td>19,0</td>
<td>4,9</td>
</tr>
<tr>
<td>Chemical Oxygen Demand</td>
<td>COD g/l</td>
<td>57,5</td>
<td>92</td>
<td>242</td>
<td>79,7</td>
</tr>
<tr>
<td>Biological Oxygen Demand</td>
<td>BOD g/l</td>
<td>15,8</td>
<td>27,6</td>
<td>72,6</td>
<td>35,4</td>
</tr>
<tr>
<td>Ratio BOD / COD</td>
<td></td>
<td>0,275</td>
<td>0,300</td>
<td>0,300</td>
<td>0,444</td>
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<tr>
<td>Total nitrogen</td>
<td>N g/l</td>
<td>3,1</td>
<td>3,5</td>
<td>16,0</td>
<td>0,87</td>
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<tr>
<td>pH-value</td>
<td>pH</td>
<td>6,5 – 7,4</td>
<td>7,1</td>
<td>7,6 – 8,0</td>
<td>4,8</td>
</tr>
<tr>
<td>Gas yield, spezific</td>
<td>l/kg ODM</td>
<td>400</td>
<td>350</td>
<td>480</td>
<td>320</td>
</tr>
</tbody>
</table>

2) Zhang et al.: Start up and operation of anaerobic EGSB treating palm oil mill effluent  
Gas yields of different substrates

- Frying fats 95% TS: 830 m³ biogas / Mg substrate
- Cheese waste 79% TS: 668 m³ biogas / Mg substrate
- Grain 87% TS: 600 m³ biogas / Mg substrate
- Old bread 65% TS: 480 m³ biogas / Mg substrate
- Chicken dung 70% TS: 260 m³ biogas / Mg substrate
- Turkey manure, straw 70% TS: 226 m³ biogas / Mg substrate
- Corn silage 35% TS: 200 m³ biogas / Mg substrate
- Rye, whole crop silage 29% TS: 176 m³ biogas / Mg substrate
- Grass wilted silage 35% TS: 147 m³ biogas / Mg substrate
- Pig dung 70% TS: 120 m³ biogas / Mg substrate
- Pig blood 19% TS: 98 m³ biogas / Mg substrate
- Flotation sludge 15% TS: 92 m³ biogas / Mg substrate
- Pig dung 35% TS: 90 m³ biogas / Mg substrate
- Cattle dung 25% TS: 86 m³ biogas / Mg substrate
- Beet leave 18% TS: 85 m³ biogas / Mg substrate
- Beet silage 12% TS: 82 m³ biogas / Mg substrate
- Vegetable waste 15% TS: 78 m³ biogas / Mg substrate
- Food waste 16% TS: 78 m³ biogas / Mg substrate
- Potato pulp 14% TS: 70 m³ biogas / Mg substrate
- Citrus pomace (without pectin) 18% TS: 35 m³ biogas / Mg substrate
- Potato stillage 6.0% TS: 24 m³ biogas / Mg substrate
- Sewage sludge (raw sludge) 5.0% TS: 24 m³ biogas / Mg substrate
- Dairy cattle manure 8.5% TS: 24 m³ biogas / Mg substrate
- Pig manure 6.0% TS: 19 m³ biogas / Mg substrate
## BIOGAS YIELD

<table>
<thead>
<tr>
<th>SUBSTRATE</th>
<th>Source</th>
<th>TS</th>
<th>TOS</th>
<th>TOS</th>
<th>Gas yield, specific</th>
<th>Methane content</th>
<th>Gas yield</th>
<th>Energy yield</th>
<th>Material input, specifically</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Energy plants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant grass</td>
<td>1</td>
<td>20,2</td>
<td>90,2</td>
<td>18,2</td>
<td>570</td>
<td>58</td>
<td>104</td>
<td>240</td>
<td>416</td>
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<tr>
<td>Guatemala grass</td>
<td>2</td>
<td>21,2</td>
<td>90,8</td>
<td>19,2</td>
<td>600</td>
<td>58</td>
<td>115</td>
<td>267</td>
<td>374</td>
</tr>
<tr>
<td>Banana skin</td>
<td>3</td>
<td>10,5</td>
<td>85,6</td>
<td>9,0</td>
<td>650</td>
<td>60</td>
<td>58</td>
<td>140</td>
<td>715</td>
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<tr>
<td>Euphorbia tirucalli</td>
<td>4</td>
<td>10,6</td>
<td>82,7</td>
<td>8,8</td>
<td>500</td>
<td>61</td>
<td>44</td>
<td>107</td>
<td>938</td>
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<tr>
<td>Rice straw</td>
<td>5</td>
<td>89,8</td>
<td>86,5</td>
<td>77,7</td>
<td>340</td>
<td>82</td>
<td>264</td>
<td>864</td>
<td>116</td>
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<tr>
<td>Sorghum</td>
<td>6</td>
<td>28,0</td>
<td>94,0</td>
<td>26,3</td>
<td>485</td>
<td>52</td>
<td>128</td>
<td>265</td>
<td>378</td>
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<tr>
<td>Water hyacinth</td>
<td>7</td>
<td>4,8</td>
<td>86,0</td>
<td>4,1</td>
<td>320</td>
<td>60</td>
<td>13</td>
<td>32</td>
<td>3.163</td>
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<tr>
<td>Alfafa silage</td>
<td>8</td>
<td>40,0</td>
<td>88,7</td>
<td>35,5</td>
<td>490</td>
<td>55</td>
<td>174</td>
<td>381</td>
<td>262</td>
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<tr>
<td>Cassava peels</td>
<td>9</td>
<td>30,0</td>
<td>93,0</td>
<td>27,9</td>
<td>660</td>
<td>51</td>
<td>184</td>
<td>375</td>
<td>267</td>
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<tr>
<td>Duck manure</td>
<td>14</td>
<td>12,5</td>
<td>83,2</td>
<td>10,4</td>
<td>500</td>
<td>64</td>
<td>52</td>
<td>133</td>
<td>753</td>
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<tr>
<td>Elephant dung</td>
<td>15</td>
<td>17,0</td>
<td>91,2</td>
<td>15,5</td>
<td>330</td>
<td>59</td>
<td>51</td>
<td>120</td>
<td>831</td>
</tr>
<tr>
<td>Rhinoceros dung</td>
<td>16</td>
<td>19,0</td>
<td>82,1</td>
<td>15,6</td>
<td>340</td>
<td>58</td>
<td>53</td>
<td>123</td>
<td>815</td>
</tr>
</tbody>
</table>

**Materials input, specifically:**

- **TS**: Total Solids
- **TOS**: Total Organic Solids
- **CH**: Vol.% CH₄
- **m₃/1000 kg FM**: Gas yield
- **kWhₑ/1000 kg FM**: Energy yield
- **kg FM/100 kWhₑ**: Material input
With the stoichiometric Buswell equation may be calculated from the empirical formula of a compound, the composition of the biogas.

\[
C_nH_aO_b + \left( n - \frac{a}{4} - \frac{b}{2} \right)H_2O \rightarrow \left( \frac{n}{2} - \frac{a}{8} + \frac{b}{4} \right)CO_2 + \left( \frac{n}{2} + \frac{a}{8} - \frac{b}{4} \right)CH_4
\]

With the extended Buswell equation also nitrogen, sulfur and phosphorus can be taken into account

\[
C_cH_hO_oN_nS_sP_p + \left( c - \frac{h}{4} - \frac{o}{2} + \frac{7n}{4} + \frac{s}{2} + \frac{7p}{4} \right)H_2O \rightarrow \\
\left( \frac{c}{2} + \frac{h}{8} + \frac{o}{4} - \frac{3n}{8} - \frac{s}{4} + \frac{5p}{8} \right)CH_4 + \left( \frac{c}{2} - \frac{h}{8} + \frac{o}{4} - \frac{5n}{8} + \frac{s}{4} + \frac{3p}{8} \right)CO_2 + n NH_4^+ + \left( n - p \right)HCO_3^- + s H_2S + p H_2PO_4^{-}
\]

Using this equation by Buswell the composition of the biogas and the aqueous phase can be calculated. Hence the buffer system can be taken into account.
Buswell - equation

Degradation starch / cellulose

\[(\text{C}_6\text{H}_{10}\text{O}_5)_n + \text{H}_2\text{O} \rightarrow 3 \text{CH}_4 + 3 \text{CO}_2\]

Degradation xylan

\[(\text{C}_5\text{H}_8\text{O}_4)_n + \text{H}_2\text{O} \rightarrow 2.5 \text{CH}_4 + 2.5 \text{CO}_2\]

Degradation proteins

\[\text{C}_{13}\text{H}_{25}\text{O}_7\text{N}_3\text{S}_1 + 9 \text{H}_2\text{O} \rightarrow 6.5 \text{CH}_4 + 3.5 \text{CO}_2 + \text{H}_2\text{S} + 3 \text{NH}_4^+ + 3 \text{HCO}_3^-\]

Degradation fat

\[\text{C}_{55}\text{H}_{104}\text{O}_6 + 26 \text{H}_2\text{O} \rightarrow 39 \text{CH}_4 + 16 \text{CO}_2\]

Biogas composition - Specific yield - water consumption

<table>
<thead>
<tr>
<th>Substance</th>
<th>Sum formula</th>
<th>CH₄</th>
<th>CO₂</th>
<th>Volume</th>
<th>Mass</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Vol.%</td>
<td>Vol.%</td>
<td>m³ Biogas/kg</td>
<td>kg Biogas/kg</td>
<td>kg H₂O/kg</td>
</tr>
<tr>
<td>Proteins</td>
<td>C_{13}H_{25}O_{7}N_{3}S_{1}</td>
<td>65.1</td>
<td>34.9</td>
<td>0.608</td>
<td>0.703</td>
<td>0.441</td>
</tr>
<tr>
<td>Triglycerids</td>
<td>C_{55}H_{104}O_{6}</td>
<td>71.0</td>
<td>29.0</td>
<td>1.426</td>
<td>1.544</td>
<td>0.544</td>
</tr>
<tr>
<td>Polysaccharides</td>
<td>(C₆H₁₀O₅)ₙ</td>
<td>50.1</td>
<td>49.9</td>
<td>0.826</td>
<td>1.111</td>
<td>0.111</td>
</tr>
<tr>
<td>Xylan</td>
<td>(C₅H₈O₄)ₙ</td>
<td>50.1</td>
<td>49.9</td>
<td>0.844</td>
<td>1.136</td>
<td>0.136</td>
</tr>
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</table>
### Buswell - equation

**EXAMPLE**

<table>
<thead>
<tr>
<th>Corn silage</th>
<th>Gas yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.0 % dry matter</td>
<td>V 201.36 m³ Biogas/1000 kg FM</td>
</tr>
<tr>
<td>96 % organic dry matter</td>
<td>V 0.636 m³ Biogas/kg ODM</td>
</tr>
</tbody>
</table>

#### Data from the literature

<table>
<thead>
<tr>
<th>Substrat</th>
<th>Eigenschaften (Substratzustand, Behandlung, Herkunft)</th>
<th>TM</th>
<th>oTM</th>
<th>Biogasertrag</th>
<th>Methan-gehalt</th>
<th>Methanertrag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% FM</td>
<td>% TM</td>
<td>Ni/kg</td>
<td>Nm³/t FM</td>
<td>%</td>
<td>Ni/kg oTM</td>
</tr>
<tr>
<td>Corn silage</td>
<td>100</td>
<td>96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>23.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellulose</td>
<td>18.4</td>
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<td></td>
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<tr>
<td>Starch</td>
<td>38.3</td>
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</tr>
<tr>
<td>Sugar</td>
<td>5.0</td>
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<tr>
<td>Protein</td>
<td>8.6</td>
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</tr>
<tr>
<td>Fat</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignine</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turnover</td>
<td>80 %</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Gas production**

- **V** 201.36 m³ Biogas/1000 kg FM
- **V** 0.636 m³ Biogas/kg ODM
- **ρ** 1.349 kg/m³
- **c_{CH4}** 52.0 Vol. % methane

**Buswell equation**

**Substrat**

- Corn silage
- Ash
- Hemicellulose
- Cellulose
- Starch
- Sugar
- Protein
- Fat
- Lignine

**Eigenschaften**

- % dry matter: 33.0
- % organic dry matter: 96

**Richtwert**

- Biogasertrag
- Methan-gehalt
- Methanertrag

**Wirtschaftsdünger**

- Geflügelmist
  - abhängig vom Stroh/Kot-Verhältnis, wenig gelagert:
    - 40 % FM
    - 75 % TM
    - 500 Ni/kg oTM
    - 150 Nm³/t FM
    - 55 % Methan-gehalt
    - 280 Ni/kg Methanertrag

- Rindermist
  - 25 % FM
  - 85 % TM
  - 450 Ni/kg oTM
  - 100 Nm³/t FM
  - 55 % Methan-gehalt
  - 250 Ni/kg Methanertrag

- Rindermüll
  - mit Futterrest
  - 10 % FM
  - 80 % TM
  - 380 Ni/kg oTM
  - 30 Nm³/t FM
  - 55 % Methan-gehalt
  - 210 Ni/kg Methanertrag

- Schweinegülle
  - 6 % FM
  - 80 % TM
  - 420 Ni/kg oTM
  - 20 Nm³/t FM
  - 60 % Methan-gehalt
  - 250 Ni/kg Methanertrag

**Nachwachsende Rohstoffe**

- Maissilage
  - 33 % FM
  - 95 % TM
  - 650 Ni/kg oTM
  - 200 Nm³/t FM
  - 52 % Methan-gehalt
  - 340 Ni/kg Methanertrag

__Fachagentur Nachwachsende Rohstoffe e. V. (FNR) 2010__

**EXAMPLE**

**Gas production**

- **V** 201.36 m³ Biogas/1000 kg FM
- **V** 0.636 m³ Biogas/kg ODM
- **ρ** 1.349 kg/m³
- **c_{CH4}** 52.0 Vol. % methane

**Substrat**

- Corn silage
- Ash
- Hemicellulose
- Cellulose
- Starch
- Sugar
- Protein
- Fat
- Lignine

**Eigenschaften**

- % dry matter: 33.0
- % organic dry matter: 96

**Richtwert**

- Biogasertrag
- Methan-gehalt
- Methanertrag

**Wirtschaftsdünger**

- Geflügelmist
  - abhängig vom Stroh/Kot-Verhältnis, wenig gelagert:
    - 40 % FM
    - 75 % TM
    - 500 Ni/kg oTM
    - 150 Nm³/t FM
    - 55 % Methan-gehalt
    - 280 Ni/kg Methanertrag

- Rindermist
  - 25 % FM
  - 85 % TM
  - 450 Ni/kg oTM
  - 100 Nm³/t FM
  - 55 % Methan-gehalt
  - 250 Ni/kg Methanertrag

- Rindermüll
  - mit Futterrest
  - 10 % FM
  - 80 % TM
  - 380 Ni/kg oTM
  - 30 Nm³/t FM
  - 55 % Methan-gehalt
  - 210 Ni/kg Methanertrag

- Schweinegülle
  - 6 % FM
  - 80 % TM
  - 420 Ni/kg oTM
  - 20 Nm³/t FM
  - 60 % Methan-gehalt
  - 250 Ni/kg Methanertrag

**Nachwachsende Rohstoffe**

- Maissilage
  - 33 % FM
  - 95 % TM
  - 650 Ni/kg oTM
  - 200 Nm³/t FM
  - 52 % Methan-gehalt
  - 340 Ni/kg Methanertrag

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COD balance

DIGESTER

COD influent → COD biogas → COD effluent

calculation COD of methane

\[ CH_4 + 2 \, O_2 \rightarrow CO_2 + 2 \, H_2O \]

1 mol CH\(_4\) = 2 mol O\(_2\)
16.04 g CH\(_4\) = 2 * 31.99 g O\(_2\)
22.4 l CH\(_4\) = 2 * 31.99 g O\(_2\)
COD CH\(_4\) = 16.04/2*31.99
  = 0.25 g CH\(_4\)
  = 0.350 NI CH\(_4\)

\[ m^3 \, CH_4 \, / \, kg \, COD_{reduced} \]

0.350 m\(^3\)/kg COD

EXAMPLE
Palm Oil Mill Effluent

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>%</th>
<th>6.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic dry matter</td>
<td>ODM</td>
<td>%</td>
<td>4.9</td>
</tr>
<tr>
<td>Chemical Oxygen Demand</td>
<td>COD</td>
<td>g/l</td>
<td>79.7</td>
</tr>
<tr>
<td>Biological Oxygen Demand</td>
<td>BOD</td>
<td>g/l</td>
<td>35.4</td>
</tr>
<tr>
<td>Ratio BOD / COD</td>
<td></td>
<td>-</td>
<td>0.444</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>N</td>
<td>g/l</td>
<td>0.87</td>
</tr>
<tr>
<td>pH-value</td>
<td>pH</td>
<td>-</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Maximum:
79.7 kg COD/m³ x 0.350 m³ CH₄/kg COD = 27.9 m³ CH₄ / m³ POME (methane)

Efficiency: 80 %
27.9 m³ CH₄ x 0.8 = 22.3 m³ CH₄/m³ POME

Methane content: 53.0 % CH₄
= 42.9 m³ biogas / m³ POME
Solid dosage

Function: mixing of solid substrates with liquid substrates or digestate

Tank of concrete
Arrangement under the floor (frost protection)
Stirrer technology is prone to of wear
Manual operation necessary
Solids settle out in the tank
High accident risk

Design type: mixing tank
Volume: 50 - 300 m³
Mixing system: agitator
Drive power: 7.5 - 15 kW
Solid dosage

System for the dosing of small fibers
Storage space for approximately one-day operation

Make : Huning
Type : SBCV
Volume : 34 m³
Drive power : 8.7 kW
Solid dosage

Make: Wangen
Type: Biomix
Design type: Throat eccentric screw pump
Performance: 40 m³/h
Drive power: 15 kW
Solid dosage

System for the dosing of small fibers
Storage space for approximately one-day operation
Solid dosage

Design type: walking floor
Volume: 100 - 200 m³
Drive power: 15 kW
Solid dosage

Design type: Vertical mixer with storage container
Volume: 20 - 250 m³
Drive power: 12.5 – 35 kW

The mixing sword can chop long fibers (eg solid manure)
Thank you!

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Our partner in Thailand

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