Biogas production of coffee pulp & waste waters
Reto Steiner, EBP, 20.6.2011
Aguas de lavado (incl. aguas mieles) o mucilago c. agua

Café fruta mala calidad, Café inmaduro

Recepción y Selección: Separación por flotación o densidad

Despulpado

Fermentación & Lavado / o Desmucilaginado mecánico

CAFÉ (52 % humedad)

Secado

Pelado y Clasificación

Café oro / grano verde (9-12% humedad)

Pulpa

Aguas de despulpado

Aguas de lavado (incl. aguas mieles) o mucilago c. agua

Cascarilla

Agua de infiltración / lixiviados
Anaerobic digestion

- Greenhouse gas emissions from pulp & waste waters could be reduced, as much as pollution of local rivers or lakes, unpleasant odours & attraction of flies and insects.

→ With adequate storage, digestion and composting.

90% less emissions due to pulp treatment possible
Anaerobic digestion of Pulp

SFOE study in 2002/2003 conducted by HSW:

- Pulp is an appropriate substrate for anaerobic digestion.
- Pulp can be digested as mono-charge.
- There are sufficient nutrients in the pulp (C:N:P = 250:10:1)
- The anaerobic digestion is not inhibited by pulp.
Anaerobic digestion of Pulp

- Biogas production, batch: 0.38 m$^3$ biogas/kg oTS, ~60 m$^3$ Biogas/m$^3$ pulp.
- Continuous digester: until 2 x more gas, test has to be repeated.
REPIC Biogas project-study (axpo, 2010)

- Biogas plant at „Beneficio Santo Domingo“, Costa Rica.
- Input: Pulp with mucilage: ~8’000 t/y
- Pulp is produced during processing period: from oct-march.
## REPIC Biogas project-study (axpo, 2010)

### Storage
- Low pH < 5.0 prevents anaerobic methane formation and favors lactic acid bacteria (silage).
- Oxygen limitation, low O2 prevents carbon degradation and energy losses.
- Coverage and rainfall protection to prevent leaching of silage juices.

### AD Dimensioning
- **Mesophilic** 32 – 38 °C
- **HRT** = 16 – 30 days
- **V.S. Load**: 5 kg/m3*d
- **V.S. Rate**: 4.2 kg/m3*d
- **Biogas Rates**:
  - 400 NL / kg V.S.
  - 60 m3 / m3 pulp

### Reactor type:
- Plug flow / recirculation
- Stirred Tank Reactor

### Substrate prone to flotation & sedimentation

### Products
- **Biogas**: 68 % CH4
- **Digestate**:
  - < 15 % D.S., requires dewatering
- **Post composting**:
  - > 8 weeks
  - high demand for turnover & aeration.
- **Liquid fertiliser**:
  - demand for structural additives (straw, wood).
  - High TN, 2 g/l
REPIC Biogas project-study (axpo, 2010)
Results

- Pulp must be stored temporarily to extend operation period of biogas plant.
- Silage of raw pulp is a solution to preserve pulp and to have available substrate for the digestor during ~ 8-9 months.
- Plant is not economic (with only 8 months operation, 8 ct.$ paid for electricity, substitution of cheap wood)
- It needs other substrates → Operation during 365 days.
- Electricity must be sold to a better price.

<table>
<thead>
<tr>
<th>Probe</th>
<th>Pulpa frisch</th>
<th>Open air</th>
<th>Open air</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alter</td>
<td>Wenige Tage</td>
<td>2 Wochen</td>
<td>2 Monate</td>
<td>3 Monate</td>
</tr>
<tr>
<td>pH</td>
<td>3.8</td>
<td>8.8</td>
<td>9.0</td>
<td>5.1</td>
</tr>
</tbody>
</table>

zhaw, U. Baier
Anaerobic digestion of waste water

- Waste water from demucilaging is adequate for anaerobic digestion:
  - Contain mucilage (aguas mieles / agua con mucilago)
  - High organic load, high sugar content
  - Also contain pectins and organic acid

- Operation is more delicate than only with pulp because of acidification (pH, results in low CH₄ content).
Anaerobic digestion of waste water

- Costa Rica: Upflow anaerobic sludge blanket (UASB) reactors have been built from 1997-2001.
- In 2005: 9 UASB-reactors in operation.
- Biogas is used in ovens with wood & parchment for coffee-bean drying.
- Biogas production: 1.3 m³ Biogas / m³ waste water with a removal efficiency of 80%.(1)
- Problems: inefficient production of biogas, tecnical problems, insufficient operation & capacitation → not optimized process.
- High costs for construction & operation are not cost-effective.
- The reactors are used to comply with the permissible value.

(1): Result from Beneficio San Juanillo, Costa Rica, Cosecha 96/97: Biogas production per day: 540 m³ Biogas / 400 m³ waste water
Conclusion (I)

- High seasonality (waste generation & energy use): 3-4 months is an important disadvantage.
- Residues require special attention (seasonal peak loads, quick biodegradation).
- Silage offers low carbon loss & low greenhouse gas emissions.
- Co-Digestion of coffee pulp and other biowastes is required to allow a continuous operation.
- Appropriate/economic technique for pulp with waste water: Stirred tank reactor.
Conclusion (II)

- Electricity production only interesting for large processing plants.
- Biogas for drying / cooking with less sophisticated digestor.
- Substitution of wood & electricity often is little cost-effective (due to low energy prices).
- In 2008 there was only very restricted willingness of coffee producers to invest in environmental technology due to the instable market situation.
- Economic benefit has to be proven today due to other surrounding conditions.