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Renewable Energy &
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Promotion in
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Biogas production of coffee pulp & waste waters

Reto Steiner, EBP, 20.6.2011

Fruto de café / café cereza

Recepción y Selección: Separación por flotación o densidad → Café fruta mala calidad, Café inmaduro

Despulpado → **Pulpa**; **Aguas de despulpado**

Fermentación & Lavado / o Desmucilaginado mecánico → **Aguas de lavado (incl. aguas mieles) o mucilago c. agua**

CAFÉ (52 % humedad)

Secado

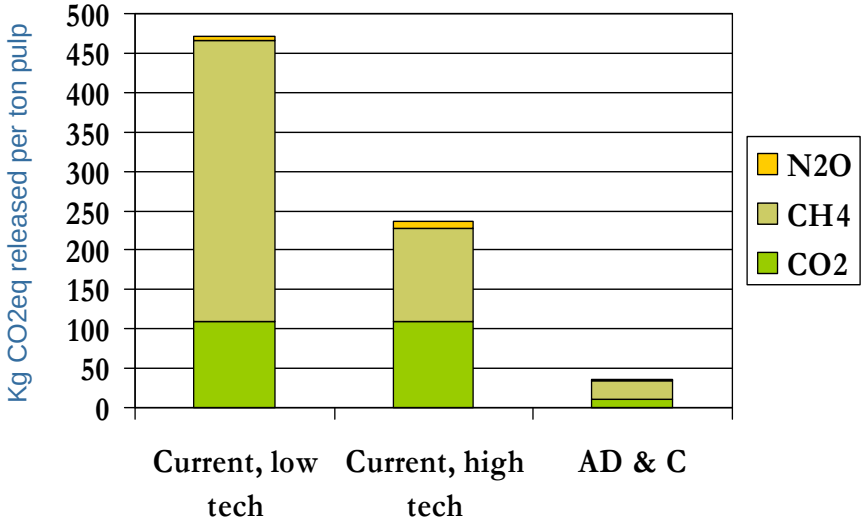
Pelado y Clasificación → **Cascarilla**

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

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 emissons 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.**

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Anaerobic digestion of Pulp

- **Biogas production, batch: 0.38 m³ biogas/kg oTS , ~60 m³ Biogas/m³ pulp.**
- **Continuous digester: until 2 x more gas, test has to be repeated.**

zhaw

Mesophile Batch Tests

Originale Pulpa:

TS 162 kg/m3

oTS = 92.8 % der TS

TN = 2.05 kg/m3

TP = 0.21 kg/m3

C : N : P = 250 : 10 : 1

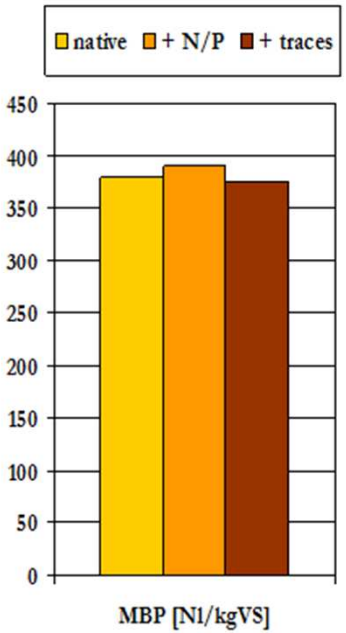
pH = 5.4

Temperatur: 36 °C

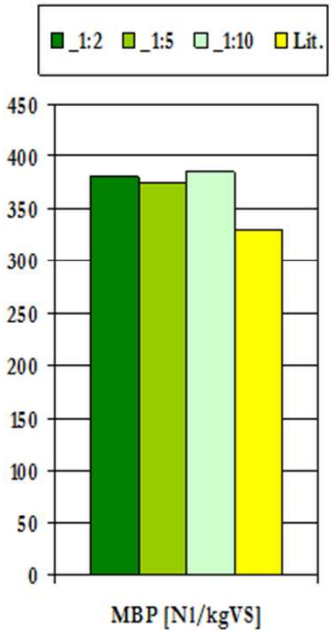
TS Abbau: 50 – 64%

oTS Abbau: 60 – 72 %

Zur Biogasproduktion hat's ausreichend Nährstoffe



Die Pulpa hemmt den anaeroben Abbau nicht.



zhaw, U. Baier

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)

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Storage

- Low pH < 5.0 prevents anaerobic methane formation and favours 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 turn-over & aeration.
- demand for structural additives (straw, wood).

Liquid fertiliser:

- High TN, 2 g/l

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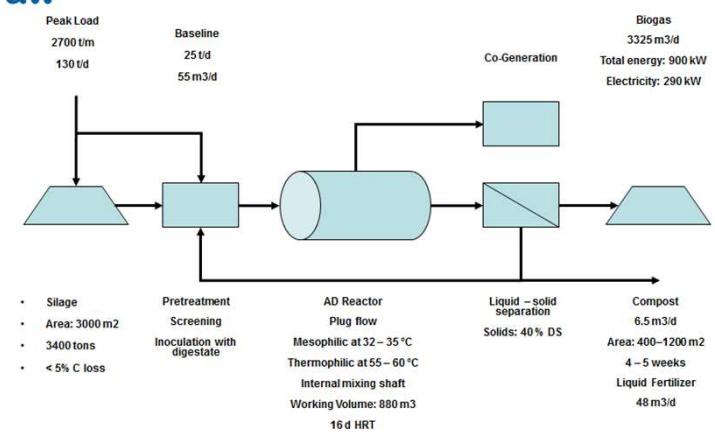

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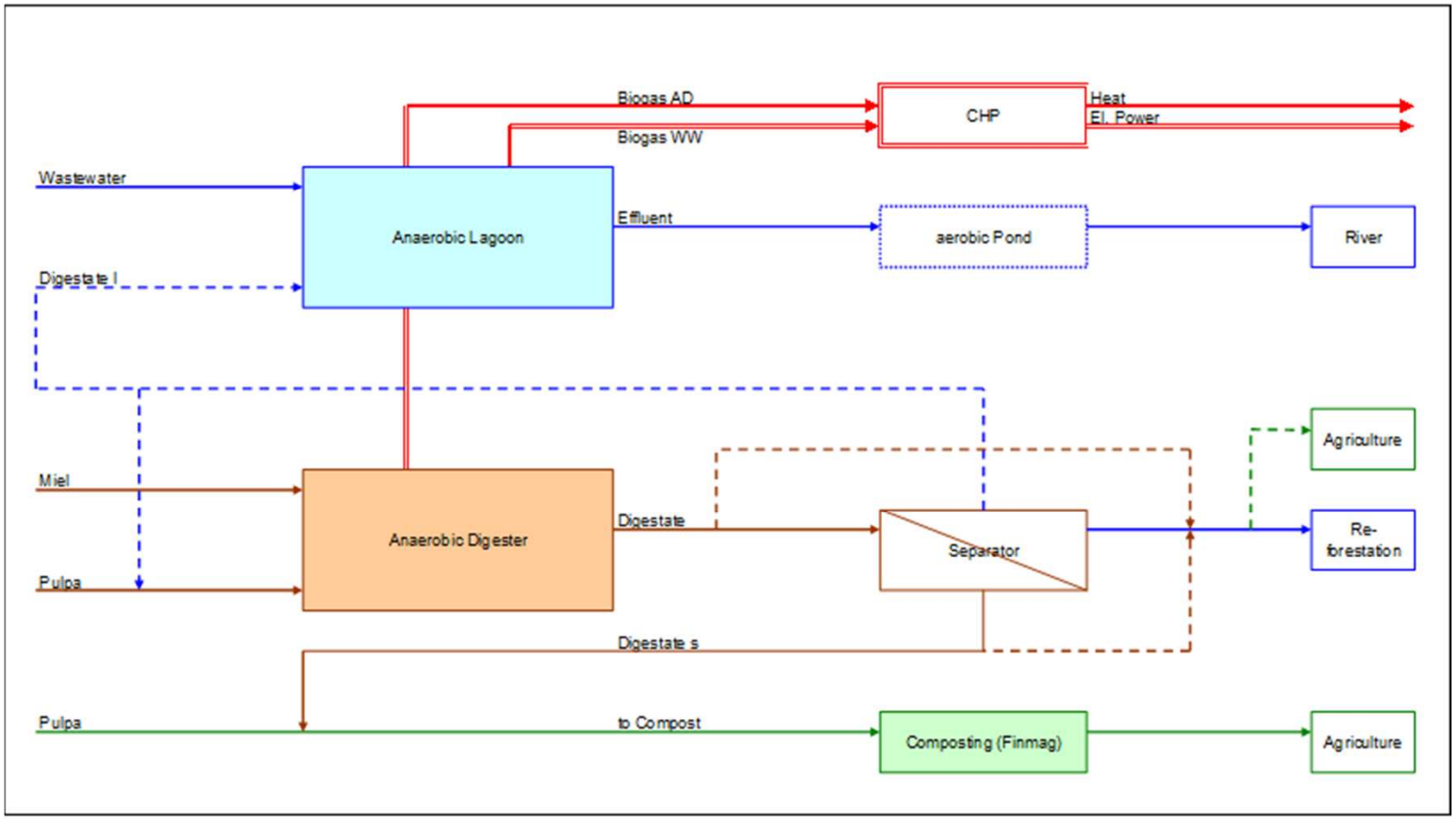

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REPIC Biogas project-study (axpo, 2010)

Results

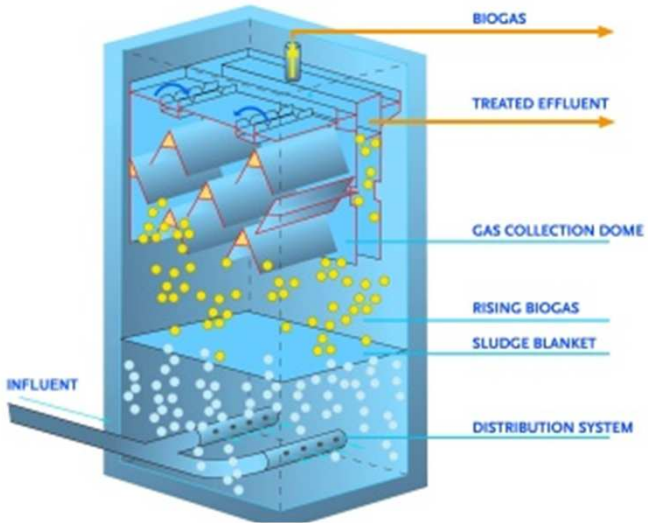
- **Pulp must be stored temporarily to extend operation period of biogas plant.**
- **Silage of raw pulp is a solution to preserve pulp and to have available substrate for the digestor during ~ 8-9 months.**
- **Plant is not economic (with only 8 months operation, 8 ct.$ paid for electricity, substitution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

zhaw, U. Baier

Probe	Pulpa frisch	Open air	Open air	Silage
Alter	Wenige Tage	2 Wochen	2 Monate	3 Monate
pH	3.8	8.8	9.0	5.1

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 suger content
  - Also contain pectins and organic acid
- **Operation is more delicate than only with pulp because of acidification (pH, results in low CH_4 content).**



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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 m^3 Biogas / m^3 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.**

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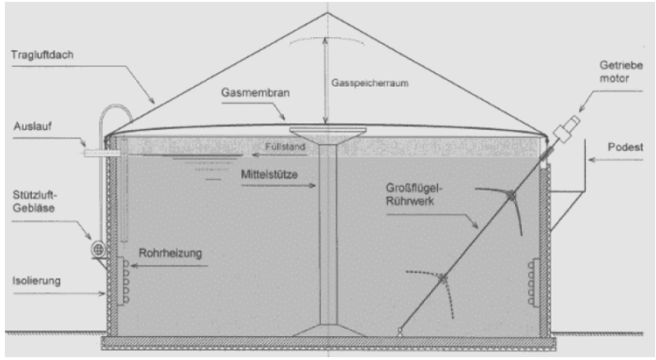
(1): Result from Beneficio San Juanillo, Costa Rica, Cosecha 96/97: Biogas production per day: 540 m3 Biogas / 400 m3 waste water

Conclusion (I)

- **High saisonality (waste generation & energy use): 3-4 months is a 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.



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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.**

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