Energy recovery and treatment of wine lees using a compact anaerobic digester

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Introduction

R&D Project:

Two goals
✓ Winery Wastewater treatment and
✓ Waste valorization – Energy recovery
Wine production

- One of the most important sectors of the Greek industry involving 470,000 tons of grapes per year

- Around 600 wineries
  most of them small or medium sized <1000tn/y
  family business

✓ Wineries present a challenge for wastewater treatment

✓ In Greece there is no common practice for winery waste management
  Discharge in sewer system
  WWTP before discharge
  Grape marcs usually used as fertilizer in fields
Winery by-products

- Grape marcs
- Wine lees
- Process wash water

- High organic load
- Most is readily biodegradable (70-80%)
- Source of energy
Scope of the work

1) Winery Wastewater characterization
2) Laboratory scale anaerobic treatment
3) Pilot plant – Results analysis
5) Cost analysis for a scale up system
6) Proposals for further optimization developments

The final aim is the design of an attractive and sustainable small – medium size system for wide scale application across the Southern Europe market.
Anaerobic digestion

• Stabilization of organic wastes
• Simple design and operation
• Mild conditions (pH, T, P)
Laboratory experiments

- 50L and 70L stirred tank reactors
- Low mixing velocity
- Temperature: 35 °C
- Inoculum: from anaerobic digester of a dairy industry

Followed on daily basis
- Biogas production
- pH
- Digester temperature

Measured twice a week
- TSS
- VSS
- Total and soluble COD
Laboratory experiments

Wine lees

• liquid fraction (supernatant)
• particulate fraction

✓ Sedimentation process
✓ Further dilution with tap water to a COD 20-35 g/L
Laboratory results

Wine lees – liquid fraction

- Operation with organic loading rate up to **10 kg/(m³ d)**
- Biogas production: **1,0 – 6,0 m³/(m³ d)**
- Biogas yield: **0,53 m³/ kg CODin** (theoretical 0,50-0,65 m³/kg CODin)
- COD removal rate **>97%**
Laboratory results

Wine lees – particulate fraction

- Displays lower degradability compared to liquid fraction
  Up to 2 kg/ (m³ d)
- Biogas production: 0.2 – 1.7 m³/(m³ d)
- COD removal rate: 88-90%
Laboratory results

Grape marc extract

- Solid/liquid: 1/3,  \( T = 20^\circ C, t = 1d \)
- COD in 30 g/L
- COD removal > 90%
- OLR: 3,5kg/(m³ d)
- Biogas production: 1,3 m³/(m³ d)
Pilot Plant – Kechris winery

- 2m³ storage tank - 3m³ anaerobic digester
- Mixer motor, electrical resistance for heating, insulation
- pH-controlled feeding system
  feed was interrupted as soon as
  the pH fell below a certain value
- Inoculum: from anaerobic digester of a dairy industry

Followed on daily basis
- Biogas production
- pH
- Digester temperature

Measured twice a week
- Total and soluble COD
- inlet – outlet – reactor
## Pilot results

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Soluble COD concentration (g/L)</th>
<th>Organic Loading Rate (g/l·d)</th>
<th>Biogas yield (m³/kg CODin)</th>
<th>COD removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wine lees</td>
<td>14-23</td>
<td>0,1-3,6</td>
<td>0,44</td>
<td>95,0</td>
</tr>
<tr>
<td>Grape marc extract</td>
<td>21-29</td>
<td>0,3-6,3</td>
<td>0,64</td>
<td>97,0</td>
</tr>
<tr>
<td>Process wash water</td>
<td>7-35</td>
<td>0,3-3,6</td>
<td>0,37</td>
<td>97,0</td>
</tr>
</tbody>
</table>
Conclusions

- The Wastewater was treated successfully

- Energy recovery:
  - 15,500 m³ biogas and 11,500 m³ methane
  - In CHP: 3,5 kWh\textsubscript{el}/m³ CH\textsubscript{4}, total 40,000 kWh\textsubscript{el}
  - Profit of 8,800 € for every winemaking season

- Present and Future development:
  - Optimization of feeding system, automation and control
  - Prototype digester design
THANK YOU