Anaerobic treatment of crude glycerol from biodiesel production

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Biodiesel is an ecological alternative of the fuel based on methyl esters of long chain fatty acids (LFCAs) designated for diesel vehicles. Biodiesel is usually produced by the process of transesterification of vegetable oils, animal fats or waste fats. In Slovak Republic, biodiesel is most frequently produced from the rape seed oil with a base catalyst and a methanol. In the process of biodiesel production a formed a heavier separate liquid phase, so named glycerol phase (g-phase). The portion of the glycerol phase representing approximately 16 - 18 % of the weight of the total oil and its composition is influenced by several factors. It contains 52 - 60 % of the glycerol, 12 - 16 % of the aldehydes especially in the form of algal soap and hydroxides, 15 - 16 % of methyl esters, 8 - 12 % of the methanol, 2 - 3 % of the water and further components. Production of biodiesel rapidly increases in the world and so does the production of crude glycerol, having a high content of organic substances. This glycerol is a suitable feedstock for anaerobic degradation.

In the work results of crude glycerol treatment in the laboratory mixed reactor and in the laboratory UASB reactors are described. Results from long-term co-digestion of maize sludge and crude glycerol in full scale anaerobic reactor at biogas plant are also discussed.

### Mixed laboratory anaerobic reactor with suspended sludge

Selected characteristics of crude glycerol in the laboratory model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COD</th>
<th>BOD₅</th>
<th>Measured values</th>
<th>Total N</th>
<th>TS</th>
<th>DIS</th>
<th>Density</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1600 mg/l</td>
<td>1200 mg/l</td>
<td>2100 mg/l</td>
<td>1200 mg/l</td>
<td>1500 mg/l</td>
<td>1000 mg/l</td>
<td>10.4</td>
<td></td>
</tr>
</tbody>
</table>

### UASB reactor

Scheme of the laboratory UASB reactor for anaerobic treatment of crude glycerol

Crude glycerol was processed in laboratory UASB reactor with suspended sludge and optimum volume of 4 litres which was operated under the temperature of 37 °C.

### Biogas production and specific biogas production

<table>
<thead>
<tr>
<th>Parameter</th>
<th>COD</th>
<th>BOD₅</th>
<th>Total N</th>
<th>Total P</th>
<th>DIS</th>
<th>Density</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured values</td>
<td>1870 mg/l</td>
<td>1085 mg/l</td>
<td>1690 mg/l</td>
<td>192 mg/l</td>
<td>1050 mg/l</td>
<td>10.4</td>
<td></td>
</tr>
</tbody>
</table>

### Cofermentation of crude glycerol with maize sludge

Two laboratory models with volume of 4 litres each were tested during the operation period, no negative influence of supplementation of the feed with crude glycerol was observed. Biogas production as well as sludge water quality were similar in both reactors.

### Results

- The sudden increase of COD and VFA concentration indicated inhibition of methanogenic processes in reactor. It was caused by the increase of dose and after decreasing the dose, processes have improved again.

- Maximum portion of g-phase added formed 41.5 % of total daily COD dose (together with maize sludge).

- Specific biogas production achieved was approximately 0.42 l/kg COD in the case of both sole maize sludge and a mixture of maize sludge with g-phase, meaning that the mixed sludge and g-phase had similar specific biogas productions per unit quantity of COD.

- On the basis of long-term operation of the laboratory scale model of anaerobic treatment of crude glycerol the following conclusions can be stated:
  - The laboratory mesophilic anaerobic degradation of crude glycerol as the only organic substrate is feasible. The process operation is very sensible to organic over-loading of reactor and process operation requires addition of small amounts of easily degradable carbon source.
  - The laboratory anaerobic treatment of crude glycerol is feasible in the case of both sole maize sludge and a mixture of maize sludge with g-phase, meaning that both the maize sludge and g-phase are suitable substrates for biogas production. Specific biogas production achieved was approximately 0.42 l/kg COD in the case of both sole maize sludge and a mixture of maize sludge with g-phase, meaning that the mixed sludge and g-phase had similar specific biogas productions per unit quantity of COD.
  - Cofermentation of crude glycerol with maize sludge in laboratory models presented that the anaerobic treatment of crude glycerol is feasible. The process operation is very sensible to organic over-loading of reactor and process operation requires addition of small amounts of easily degradable carbon source.
  - The laboratory anaerobic treatment of crude glycerol is feasible in the case of both sole maize sludge and a mixture of maize sludge with g-phase, meaning that both the maize sludge and g-phase are suitable substrates for biogas production. Specific biogas production achieved was approximately 0.42 l/kg COD in the case of both sole maize sludge and a mixture of maize sludge with g-phase, meaning that the mixed sludge and g-phase had similar specific biogas productions per unit quantity of COD.