Anaerobic digestion of hydrothermal liquefaction wastewater and biochar from spent coffee grounds
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23 years old

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Maria Eduarda Dias
Introduction

Figure 1. Evolution of global coffee consumption growth.


Figure 2. Coffee cycle resume.

Source: Dattatraya Saratale et al., 2020.
Introduction

Figure 3. Hydrothermal liquefaction abstract.

Source: Gu et al., 2020.

Figure 4. Sample of PHWW from HTL of SCG.
Purpose

This research aimed at the soluble organic content reduction and the methane recovering from the post hydrothermal liquefaction wastewater (PHWW) of SCG through the anaerobic digestion process enhanced by the addition of activated carbon and biochar, the co-product of the HTL process, as adsorbents.
Methods

Hydrothermal Liquefaction

Spent Coffee Grounds

Bio-oil

PHWW

Solid Residue

Parr Reactor
275°C
10 min

Separation

Inoculum

PHWW

ASR

GAC

First and Second Exposition

Activation Process

ASR

Third Exposition
Results – Adsorption

Table 1. Adsorption capacity of ASR and GAC.

<table>
<thead>
<tr>
<th></th>
<th>ASR</th>
<th>GAC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Efficiency removal (%)</td>
<td>$q_e$ (mg. g$^{-1}$)</td>
</tr>
<tr>
<td>COD</td>
<td>7.3 ± 0.7</td>
<td>443.3 ± 61,2</td>
</tr>
<tr>
<td>Phenols</td>
<td>7.0 ± 5.2</td>
<td>33.2 ± 24,5</td>
</tr>
</tbody>
</table>

Whereas: $%R$ is removal efficiency, $q_e$ is adsorption capacity (mg·g$^{-1}$), $c_i$ is initial concentration (mg·L$^{-1}$), $c_f$ is final concentration (mg·L$^{-1}$), $v$ is nominal volume (L) and $m$ is mass of adsorbent (g).
## Results – Anaerobic Digestion

Table 2. COD and total phenols values measured during the incubation period. AD is anaerobic digestion, GAC is activated carbon and ASR is activated solid residue

<table>
<thead>
<tr>
<th>Studied AD condition</th>
<th>Adsorbent addition</th>
<th>COD (g·L⁻¹)</th>
<th>COD efficiency removal (%)</th>
<th>Phenols (mg·L⁻¹)</th>
<th>Phenols efficiency removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Affluent</td>
<td>Effluent</td>
<td>Affluent</td>
<td>Effluent</td>
</tr>
<tr>
<td>First Exposition</td>
<td>No</td>
<td>1.43 ± 0.07</td>
<td>0.67 ± 0.01</td>
<td>53.06</td>
<td>66.9 ± 0.0</td>
</tr>
<tr>
<td>Second Exposition</td>
<td>No</td>
<td>2.21 ± 0.01</td>
<td>1.21 ± 0.01</td>
<td>45.16</td>
<td>198.7 ± 30.0</td>
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<tr>
<td></td>
<td>No</td>
<td>2.42 ± 0.26</td>
<td></td>
<td>54.24</td>
<td></td>
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<tr>
<td>Third Exposition</td>
<td>GAC</td>
<td>5.29 ± 1.69</td>
<td>1.59 ± 0.04</td>
<td>69.84</td>
<td>410.34 ± 15.28</td>
</tr>
<tr>
<td></td>
<td>ASR</td>
<td>2.23 ± 0.23</td>
<td></td>
<td>57.78</td>
<td></td>
</tr>
</tbody>
</table>
Results – Methane production profile

Figure 5. Methane production profile experimental data and exponential equation adjust.

Figure 6. Accumulated methane experimental potential and the theoretical methane potential (maximum).
Results – Gompertz parameters

Table 3. Curve fitting for methane profile production (Exponential and Modified Gompertz equations) and methane yields (experimental and theoretical).

<table>
<thead>
<tr>
<th>Experimental set</th>
<th>Exponential</th>
<th>Mod Gompertz</th>
<th>Methane Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k (h⁻¹)</td>
<td>Total CH₄ (NmL)</td>
<td>k (d⁻¹)</td>
</tr>
<tr>
<td>AD</td>
<td>0.0055</td>
<td>14.82</td>
<td>2.47</td>
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<tr>
<td>AD plus CBC</td>
<td>0.0072</td>
<td>29.39</td>
<td>3.45</td>
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<tr>
<td>AD plus GAC</td>
<td>0.0119</td>
<td>39.62</td>
<td>6.28</td>
</tr>
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</table>

modified Gompertz equation: \( P_{CH₄}(t) = P_{CH₄} \cdot \exp\left\{-\exp\left[\frac{k \cdot e}{P_{CH₄}} (\lambda - t) + 1\right]\right\} \)  Equation (x)

Where \( P_{CH₄}(t) \) (NL CH₄) is the methane produced at any time \( t \), \( P_{CH₄} \) maximum methane cumulated potential (mL CH₄), \( k \) is the maximum rate of methane production (NL·h⁻¹), \( \lambda \) is the lag phase time constant (h) and \( t \) is the incubation period (h).
Conclusion

• ASR showed the capacity of removing $443.3 \pm 61.2 \text{ mgCOD g}^{-1}\text{ASR}$ (56% of CAG removal capacity) and $33.2 \pm 24.5 \text{ mg phenols g}^{-1}\text{ASR}$ (47% of GAC removal capacity) from the PHWW by adsorption.

• The ASR adsorption capacity proved to be potentially interesting as an alternative to the GAC use as adsorbent when anaerobic digesting PHWW.

• Increasing COD removal efficiency from 54% (PHWW-AD) to 58% (PHWW-AD with ASR); increasing phenols removal efficiency from 36% (PHWW-AD) to 45% (PHWW-AD with ASR) and increasing Methane Yield from $77 \text{ mLCH}_4 \text{ gCOD}^{-1}$ (PHWW-AD) to $125 \text{ mLCH}_4 \text{ gCOD}^{-1}$ (PHWW-AD with ASR).

• Furthermore, the ASR addition to the PHWW-AD process has contributed to the increase in the modified Gompertz parameter of methane production maximum rate in 40%. It was also concluded that PHWW and ASR co-digestion can potentially reduce inoculum acclimatization periods to the recalcitrance compounds of the PHWW.
Acknowledgements
References


Figures References

