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

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23 years old

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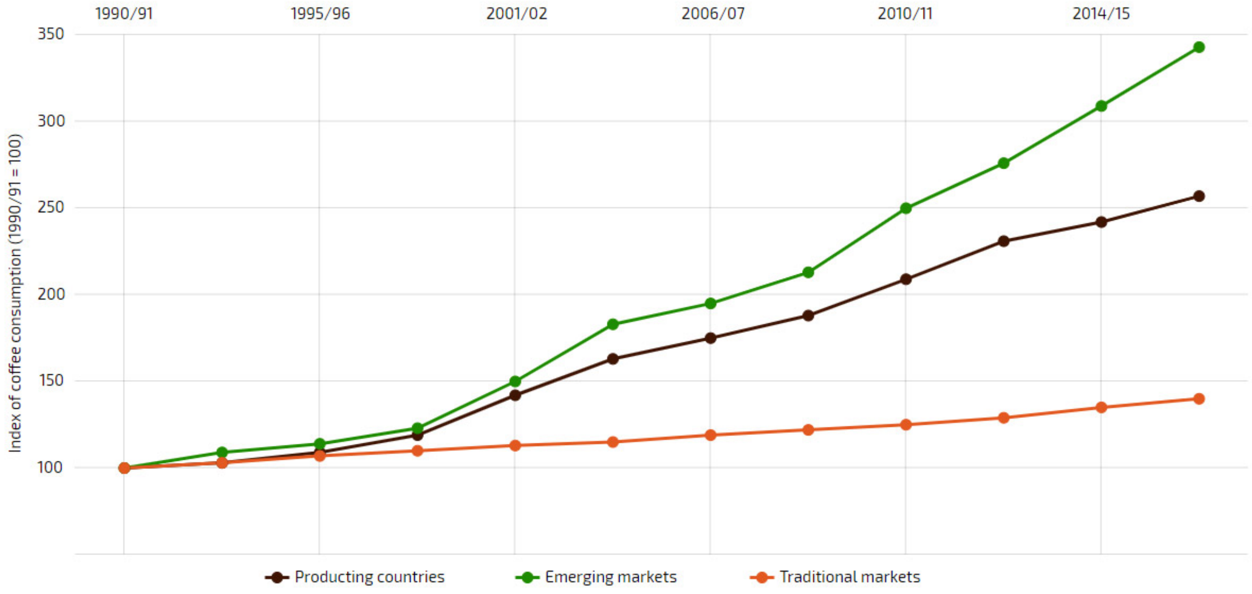
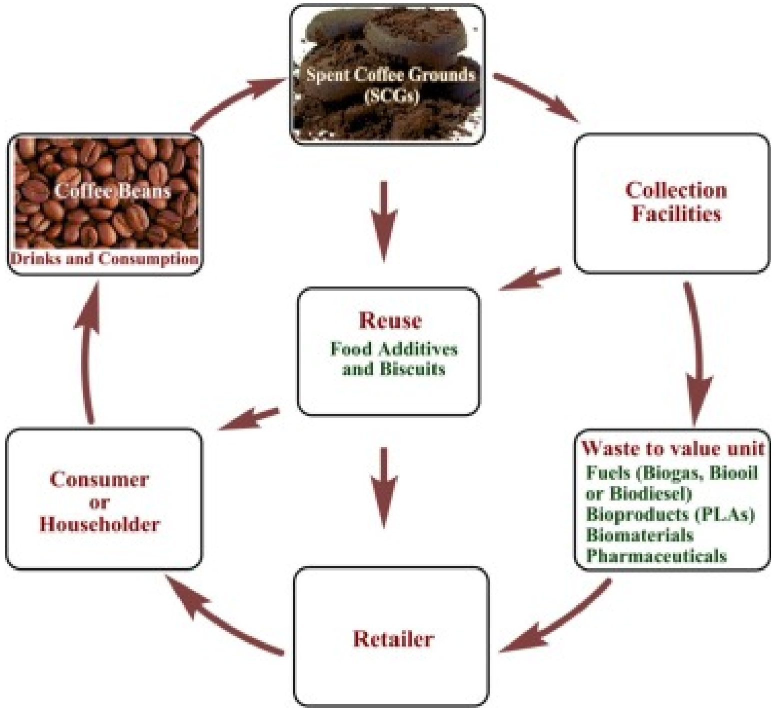
Introduction

Figure 1. Evolution of global coffee consumption growth.



Source: Coffee Statistics, 2021.

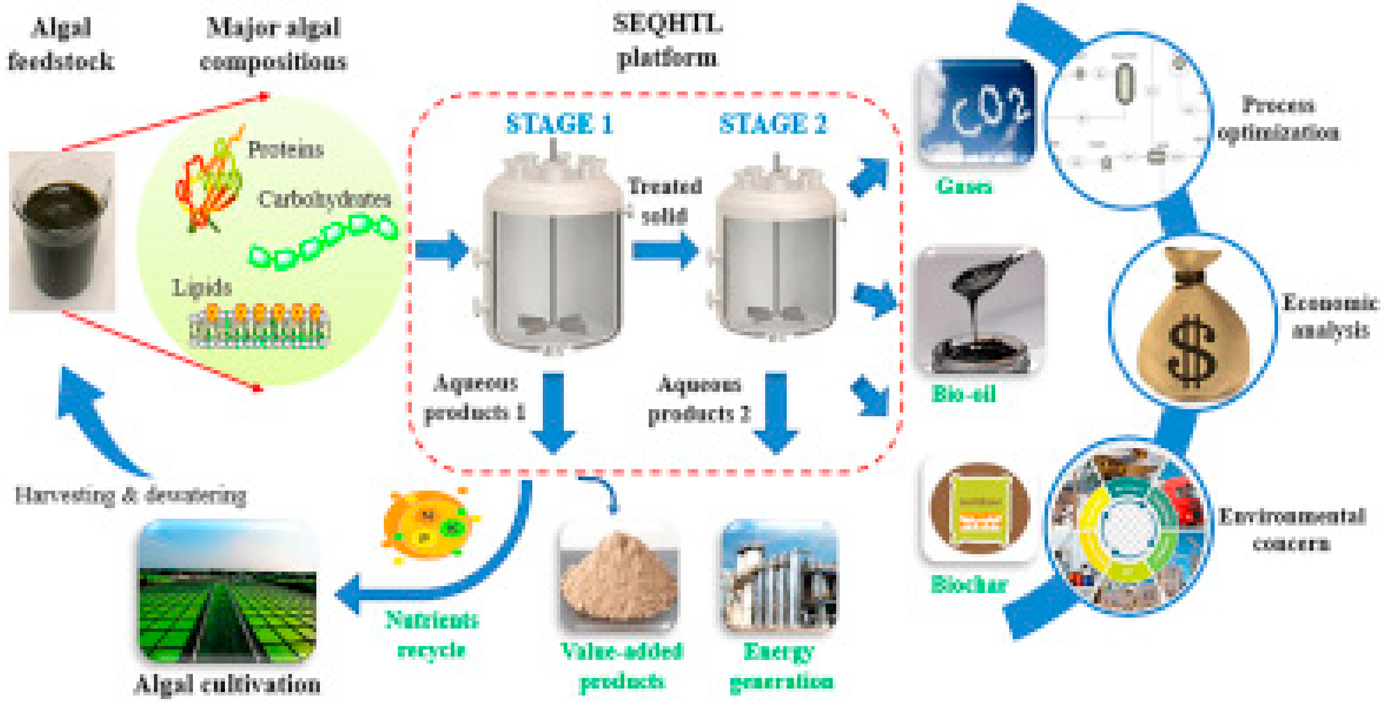
Figure 2. Coffee cycle resume.



Source: Dattatraya Saratale et al., 2020.

Introduction

Figure 3. Hydrothermal liquefaction abstract.

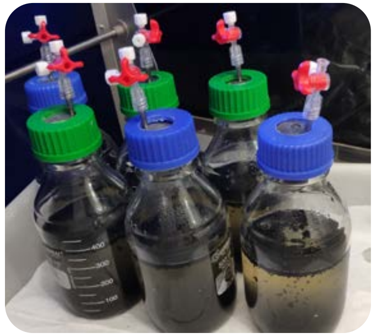


Source: Gu et al., 2020.

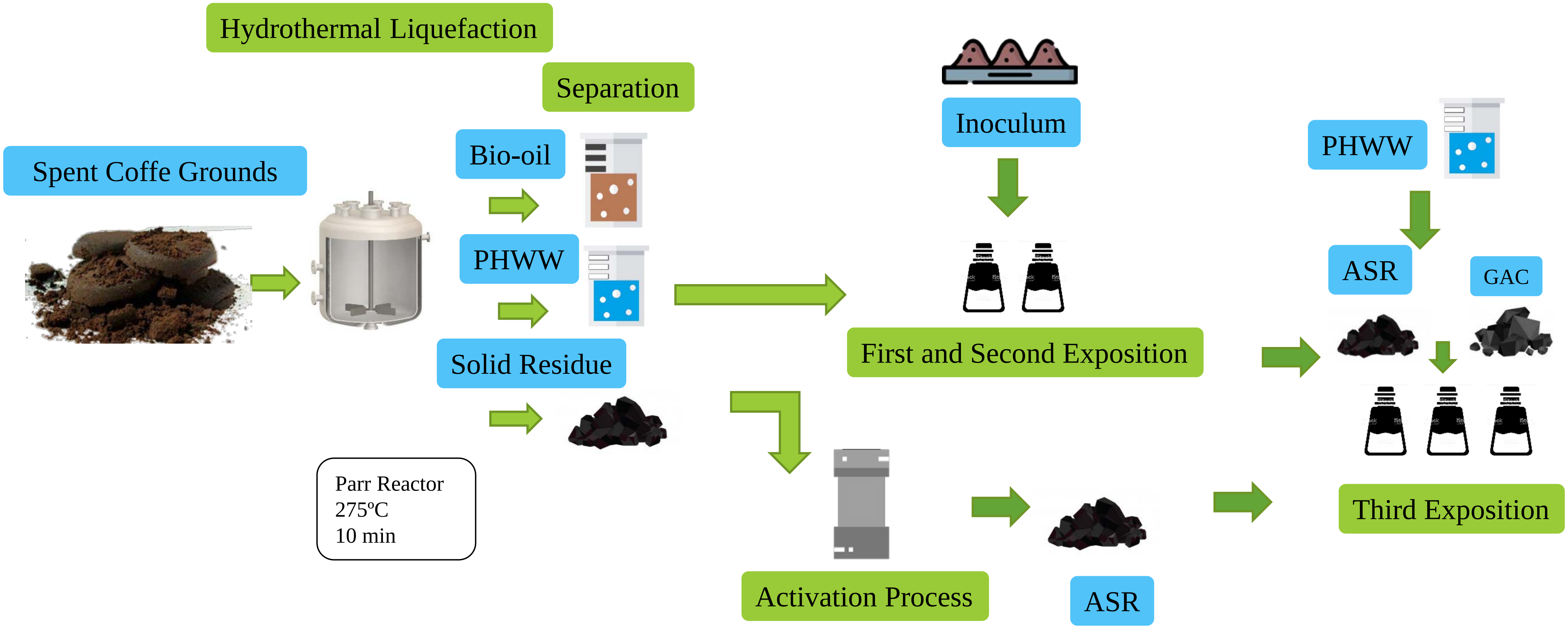
Figure 4. Sample of PHWW from HTL of SCG.

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
Separation
Spent Coffe Grounds
Bio-oil
PHWW
Solid Residue
Parr Reactor
275ºC
10 min
Inoculum
First and Second Exposition
Activation Process
ASR
PHWW
ASR
GAC
Third Exposition

Results – Adsorption

Table1. Adsorption capacity of ASR and GAC.

	ASR		GAC	
	Efficiency removal (%)	q_e (mg. g^{-1})	Efficiency removal (%)	q_e (mg. g^{-1})
COD	7.3 ± 0.7	443.3 ± 61,2	12.1 ± 2.7	79.,9 ± 175.1
Phenols	7.0 ± 5.2	33.2 ± 24,5	15.0 ± 6.2	71.0 ± 29.3

$$\%R = \frac{(C_i - C_f)}{C_i} \cdot 100 \quad \text{Equation (1)}; \quad q_e = \frac{(C_i - C_f) \cdot V}{m} \quad \text{Equation (2)}$$

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

Studied AD condition	Adsorbent addition	COD ($g \cdot L^{-1}$)		COD efficiency removal (%)	Phenols ($mg \cdot L^{-1}$)		Phenols efficiency removal (%)
		Affluent	Effluent		Affluent	Effluent	
First Exposition	No	1.43 ± 0.07	0.67 ± 0.01	53.06	66.9 ± 0.0	62.1 ± 5.3	7.18
Second Exposition	No	2.21 ± 0.01	1.21 ± 0.01	45.16	198.7 ± 30.0	165.1 ± 6.2	16.90
Third Exposition	No	5.29 ± 1.69	2.42 ± 0.26	54.24	410.34 ± 15.28	262.39 ± 9.13	36.05
	GAC		1.59 ± 0.04	69.84		156.18 ± 3.27	61.94
	ASR		2.23 ± 0.23	57.78		224.06 ± 10.57	45.40

Results – Methane production profile

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

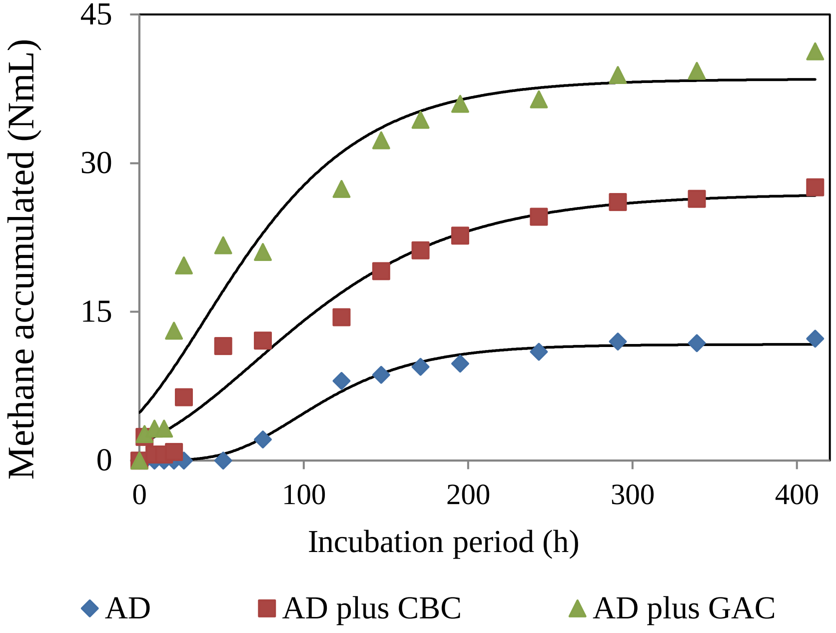
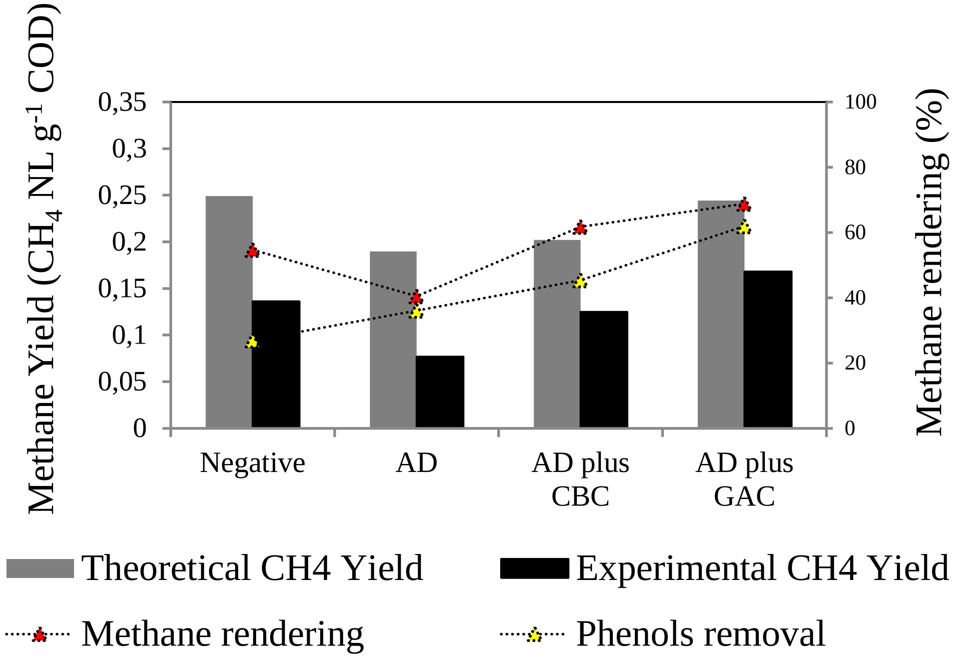


Figure 6. Accumulated methane experimental potential and the theoretical methane potential (maximum).



Results – Gompertz parameters

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

Experimental set	Exponential		Mod Gompertz			Methane Production	
	k (h-1)	Total CH_4 (NmL)	k (d-1)	Total CH_4 (NmL)	lag (d)	CH_4 Yield (*) LCH_4 g^{-1} COD	Theoretical CH_4 Yield (*) LCH_4 g^{-1} COD
AD	0.0055	14.82	2.47	11.7	2,24	76.83	189.84
AD plus CBC	0.0072	29.39	3.45	26.93	0.0489	124.91	202.24
AD plus GAC	0.0119	39.62	6.28	38.48	-0.61	168.18	244.44

modified Gompertz equation : $P_{CH_4}(t) = P_{CH_4} \cdot exp\left\{-exp\left[\frac{k \cdot e}{P_{CH_4}}(\lambda - t) + 1\right]\right\}$ Equation (x)

Where $P_{CH_4}(t)$ (NL CH_4) is the methane produced at any time (t), P_{CH4} maximum methane cumulated potential (mL CH_4), k is the maximum rate of methane production ($NL \cdot h^{-1}$), λ is the lag phase time constant (h) and t is the incubation period (h).

Conclusion

- ASR showed the capacity of removing 443.3 ± 61.2 mgCOD g^{-1}ASR (56% of CAG removal capacity) and 33.2 ± 24.5 mg phenols g^{-1}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 mLCH4 $gCOD^{-1}$ (PHWW-AD) to 125 mLCH4 $gCOD^{-1}$ (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

FAPESP

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FZEA USP

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Figures References

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