8th European Bioremediation Conference EBC-VIII

Integral valorization of agricultural waste by hydrothermal co-carbonization

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Garden and park waste (GPW) (high C, low N, P)

Swine manure (SM) (low C, high N, P)

Hydrothermal co-carbonization

T = 180 ºC
t = 60 min
3 SM:GPW ratios:
(3:1 – 1:1 – 1:3)

Hydrochar (HC)

ISO 17225-8 Solid biofuels specifications

HHV > 17 MJ/kg
N < 3% - S < 0.5%
VM < 75%

Use as biofuel

Gas (CO_2, CO, H_2O)

Process water (PW) (Organic compounds, N, P)

Nutrient recovery

Ca Mg K N P

Struvite

Use as biofertilizer

Anaerobic digestion

Biogas

Use as biofuel

Anaerobic digestion

Biogas

Use as biofuel

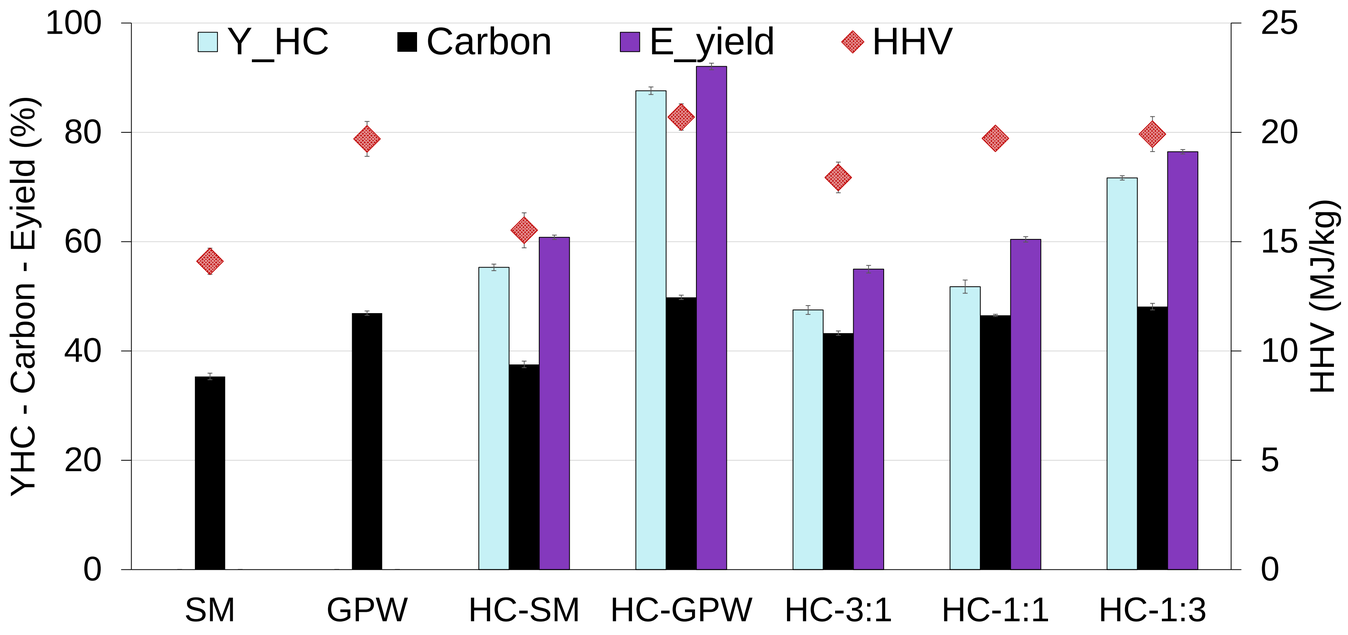
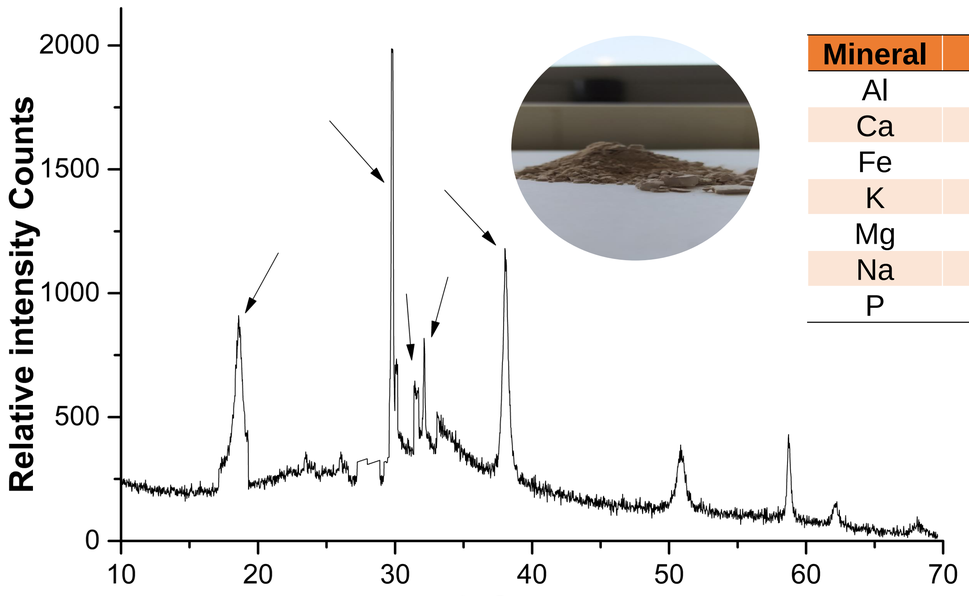


Figure 1. Energy characteristics of HC obtained in HTC of GPW, SM and co-HTC of GPW:SM

Hydrochar from co-HTC present suitable characteristics:

- Higher heating value: 18 – 21 MJ/kg
- N: 1.5 – 2.3 %
- S: < 0.2 %
- Volatile matter: 60 – 70 %

to be used as a source of energy without any restriction according to ISO/TS 17225-8 (2016).



Mineral	g/kg
Al	0.5
Ca	7.8
Fe	0.2
K	20.7
Mg	101.2
Na	13.8
P	77.9

Heavy Metals	mg/kg
Cd	0.4
Cr	5.2
Cu	8.0
Ni	3.2
Pb	3.2
Zn	348.9

Ultimate analysis (%)	
C	7.3
H	2.49
N	2.13
S	0.14

The structure of the recovered solid presents peaks belonging to struvite, apatite, and hydroxyapatite. The solid recovered from PW-3:1 presented a high nutrient content (NPK 2.1/7.8/2.1) and low content of heavy metals.

The co-HTC promoted the swine manure P solubilisation up to 75%, while the plain HTC of SM only 15% was solubilized to the PW

Figure 2. Analysis of solid recovered from PW

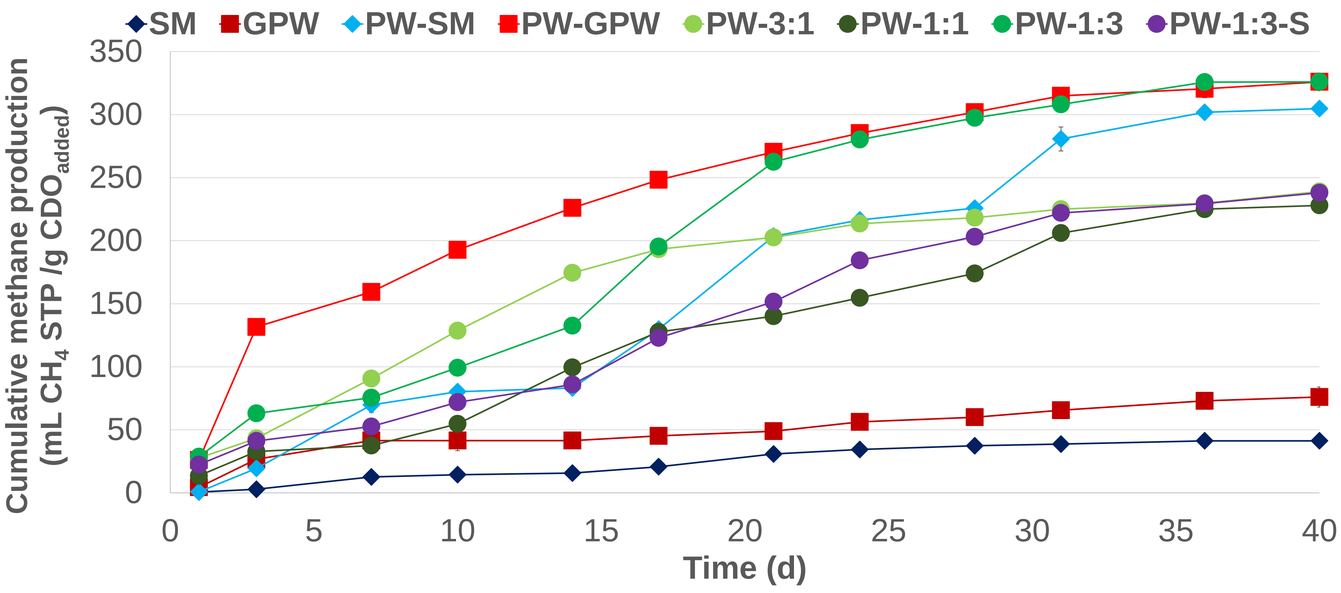


Figure 3. Cumulative methane production

Anaerobic digestion of PW reached methane production between 230 – 330 mL CH_4 g^{-1} COD_{added} and organic matter removal of 30 – 65%.

ACKNOWLEDGEMENTS

Authors greatly appreciate funding from Spain's MINECO (PID2019-108445RB-I00, PDC2021-120755-I00), Madrid Regional Government (Project S2018/EMT-4344) and Grupo Kerbest Company. R.P. Ipiales acknowledges financial support from Community of Madrid (IND2019/AMB-17092) and Arquimea-Agrotech Company.

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