Continuous hydrothermal treatment for efficient management of biomass wastes

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carbon 2023 · Cancun · Mexico
The World Conference on Carbon

Introduction

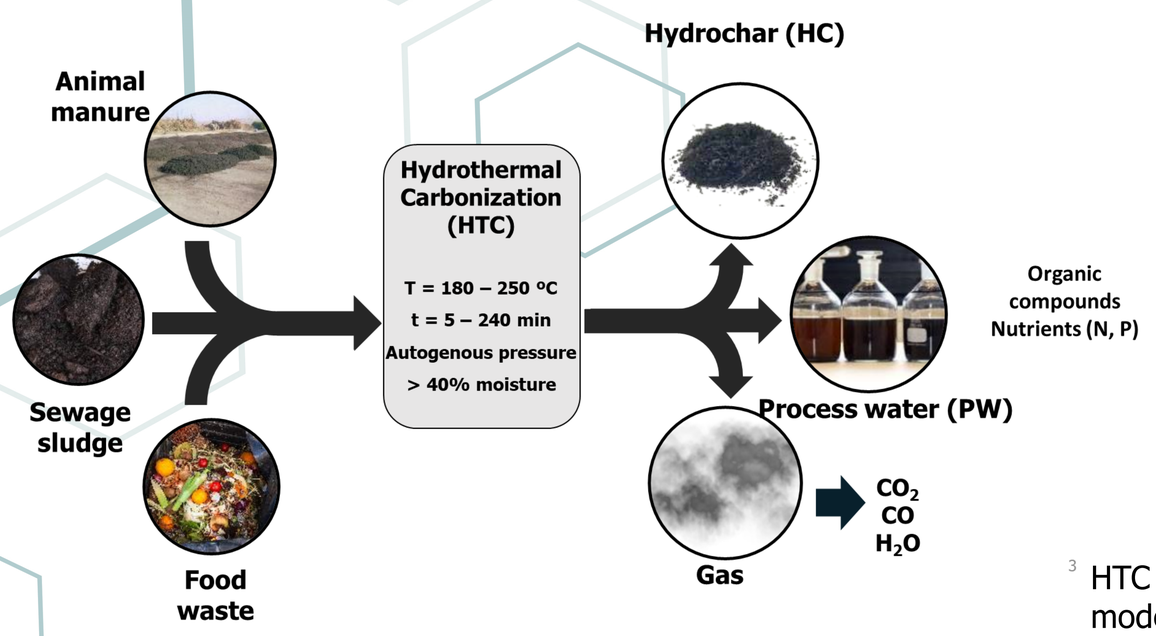
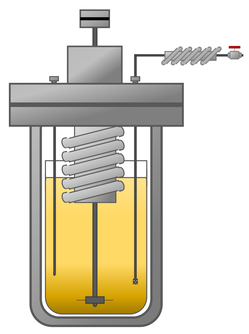


Figure 1. Hydrothermal carbonization process

Materials and methods



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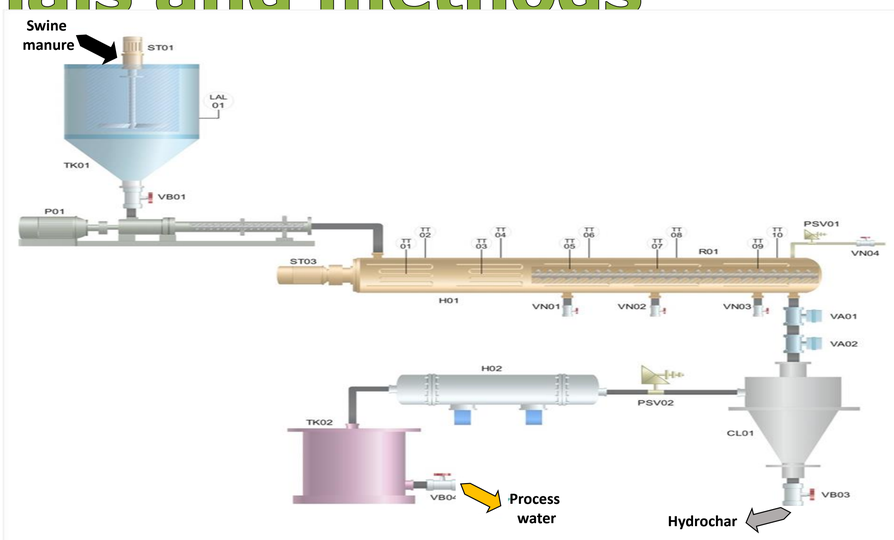

Figure 2. Scheme of continuous and batch hydrothermal carbonization reactor

HTC runs in continuous mode was performed in ARQUIMEA – HTC unit, while HTC runs in batch mode were carried out in an electrically heated ZipperClave® pressure vessel of 4L at same operational conditions of continuous runs. In each sequence, swine manure (SM) with a total solid content ≈ 5% were carried out at 180, 210, 230 and 250 ºC and resident time 45 min. Hydrochar and process water were denoted according to the carbonization temperature and a letter C and B of continuous and batch process respectively, i.e., HC180-C, HC210-C, HC230-C and HC250-C.

Results and discussion

Table 1. Main characteristics of swine manure and hydrochars

	Y_{HC} (%)	VM (%)	Ash (%)	C (%)	N (%)	S (%)	HHV (MJ kg^{-1})
	-	75.8 (0.1)	10.5 (0.1)	45.0 (0.4)	1.4 (0.0)	0.5 (0.0)	18.5 (0.2)
HC180-C	71.8 (3.1)^{a}	69.6 (0.3)^{a}	5.5 (0.2)^{a}	47.1 (0.6)^{a}	0.8 (0.1)^{a}	0.3 (0.0)^{a}	18.8 (0.1)^{a}
HC210-C	52.4 (2.4)^{b}	75.0 (0.4)^{b}	3.7 (0.1)^{b}	50.4 (0.3)^{b}	1.6 (0.3)^{b}	0.4 (0.0)^{b}	20.3 (0.3)^{b}
HC230-C	46.2 (1.9)^{c}	73.8 (0.2)^{b}	3.9 (0.2)^{b}	51.5 (0.6)^{c}	1.4 (0.1)^{c}	0.2 (0.0)^{c}	20.7 (0.3)^{c}
HC250-C	22.7 (0.6)^{d}	72.9 (0.2)^{c}	3.9 (0.2)^{b}	51.7 (0.5)^{c}	1.2 (0.0)^{d}	0.4 (0.0)^{b}	20.9 (0.2)^{c}
HC180-B	42.9 (0.4)^{e}	71.5 (0.4)^{d}	3.2 (0.1)^{b}	50.0 (0.6)^{b}	1.4 (0.0)^{c}	0.3 (0.0)^{a}	19.9 (0.3)^{b}
HC210-B	40.1 (0.5)^{e}	71.9 (0.3)^{d}	3.9 (0.2)^{b}	52.2 (0.6)^{c}	1.4 (0.1)^{c}	0.3 (0.0)^{a}	20.5 (0.4)^{b,c}
HC230-B	35.2 (1.0)^{f}	71.6 (0.4)^{d}	3.8 (0.2)^{b}	53.0 (0.1)^{d}	1.5 (0.0)^{b}	0.3 (0.0)^{a}	21.0 (0.1)^{c}
HC250-B	19.9 (0.6)^{g}	68.7 (0.1)^{e}	6.3 (0.2)^{c}	54.8 (0.3)^{d}	1.9 (0.0)^{d}	0.5 (0.0)^{d}	25.0 (0.2)^{d}

Table 2. Process water characteristics obtained in continuous and batch HTC

	TCOD (g L^{-1})	TOC (g L^{-1})	pH	TN (g L^{-1})	P-P0$_4$ (mg L^{-1})
PW180-C	6.5 (0.2)^{a}	3.5 (0.1)^{a}	6.0 (0.2)^{a}	173.0 (2.4)^{a}	48.3 (0.5)^{a}
PW210-C	10.2 (0.6)^{b}	6.1 (0.1)^{b}	4.4 (0.4)^{b}	267.0 (2.2)^{b}	68.3 (0.4)^{b}
PW230-C	11.0 (0.5)^{b}	7.2 (0.2)^{c}	4.0 (0.1)^{b}	294.0 (2.5)^{c}	68.3 (0.4)^{b}
PW250-C	12.6 (0.7)^{c}	11.0 (0.3)^{d}	4.2 (0.1)^{b}	238.8 (4.5)^{d}	85.3 (0.1)^{c}
PW180-B	16.3 (0.2)^{d}	8.1 (0.2)^{e}	4.3 (0.4)^{b}	617.0 (3.4)^{e}	64.3 (0.3)^{b}
PW210-B	19.8 (0.5)^{e}	9.5 (0.4)^{f}	4.2 (0.1)^{b}	641.0 (1.8)^{f}	38.0 (0.1)^{e}
PW230-B	21.2 (0.5)^{f}	9.9 (0.1)^{f}	3.8 (0.2)^{b}	675.2 (1.6)^{g}	40.8 (0.2)^{f}
PW250-B	19.9 (0.4)^{e}	9.7 (0.2)^{f}	5.1 (0.2)^{c}	800.0 (1.5)^{h}	52.3 (0.2)^{g}

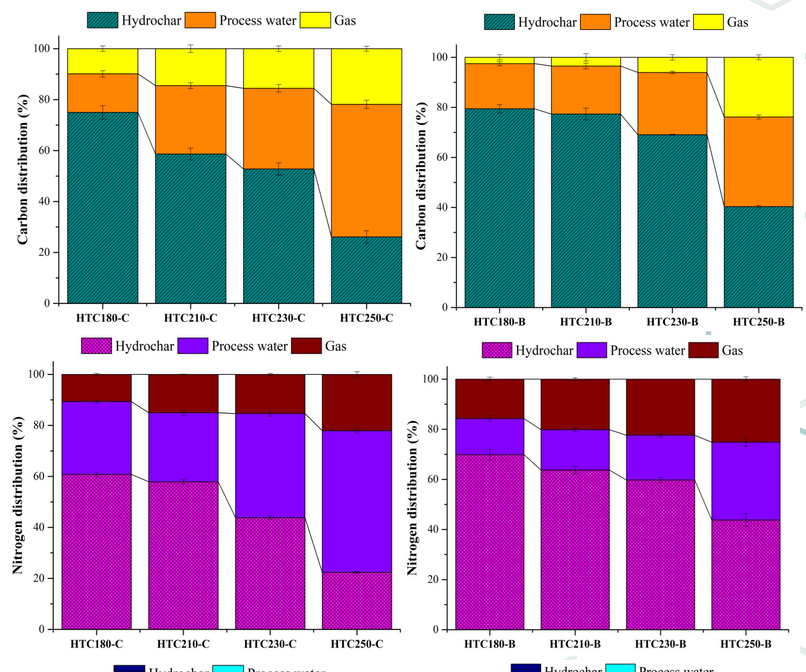

Figure 3. Distribution of main element in hydrochar, process water and gas fraction, Carbon, Nitrogen, Sulfur and Phosphorus

Conclusions

- The continuous HTC process resulted in a hydrochar with enhanced characteristics with respect to the feedstock and a process water with high organic matter and nutrient (N, P and minerals) content
- The hydrochar showed characteristics suitable for industrial use as a solid biofuel according to ISO/TE 17225-8 (HHV > 17 MJ kg-1, N < 3 wt.%, S < 0.5 wt.%, MV < 75 wt.%, and ash < 10 wt.%)
- The implementation of a continuous HTC process in an intensive farm could be an efficient pathway for the valorization and management of swine manure, allowing to obtain value-added products (hydrochar, biogas and P-rich minerals) compared to the product (compost) obtained in the traditional management of swine manure

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