Biomass valorization by Hydrothermal Carbonization and Anaerobic Digestion

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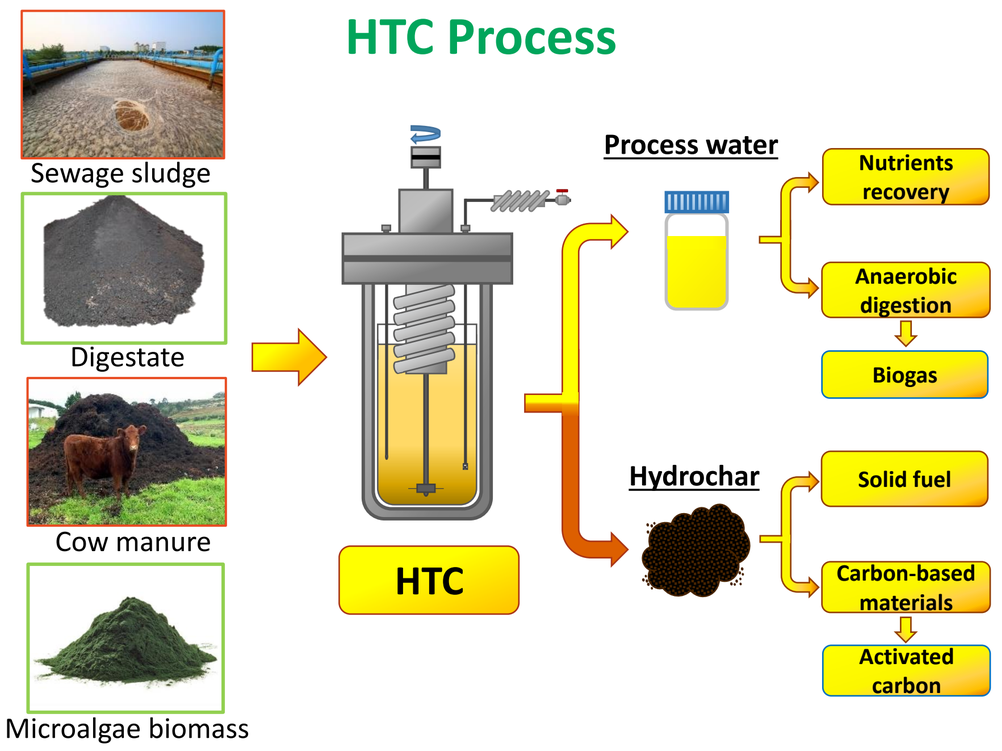
Introduction

Thermochemical conversion processes are typically used to convert biomass into valuable products or biofuel. Specifically, hydrothermal carbonization (HTC), carried out at 180–260 ºC under auto-generated pressure, is a promising method for wet biomass valorization. HTC converts residual biomass, with a high moisture content (sewage sludge (SS), digestate, manure, microalgae, etc.), into a valuable solid product, usually called hydrochar (HC), in addition to a process water (PW) and a gas stream.

HC can be used as solid fuel due to the high higher heating value (> 20 MJ kg^{-1}). HC can be valorized by physical or chemical activation to obtain activated carbon, that can be used as adsorbents or catalytic supports. On the other hand, PW, with a large amount of organic matter, can be used as a substrate for anaerobic digestion (AD). Moreover, the PW contains a high nutrient concentration (N, P, and K) which can be recovered for the production of fertilizers.

HTC Process



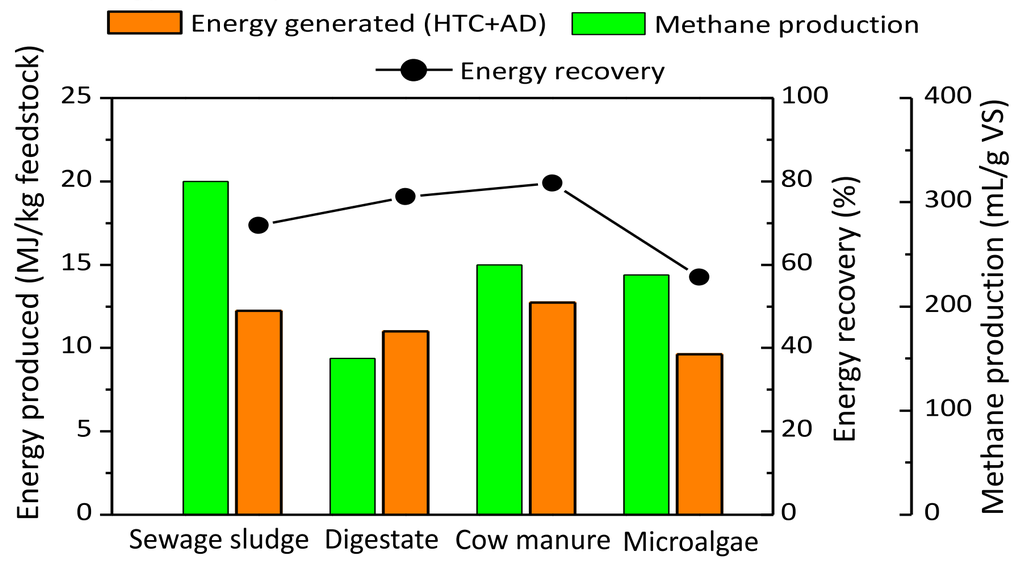
Current research

Energy recovery from HTC

HC as solid fuel with high energy density can be blended with other biomass residues to improve the thermal characteristics and combustion behavior. The methane produced by AD of the PW from HTC allows to increase the energy recovery.

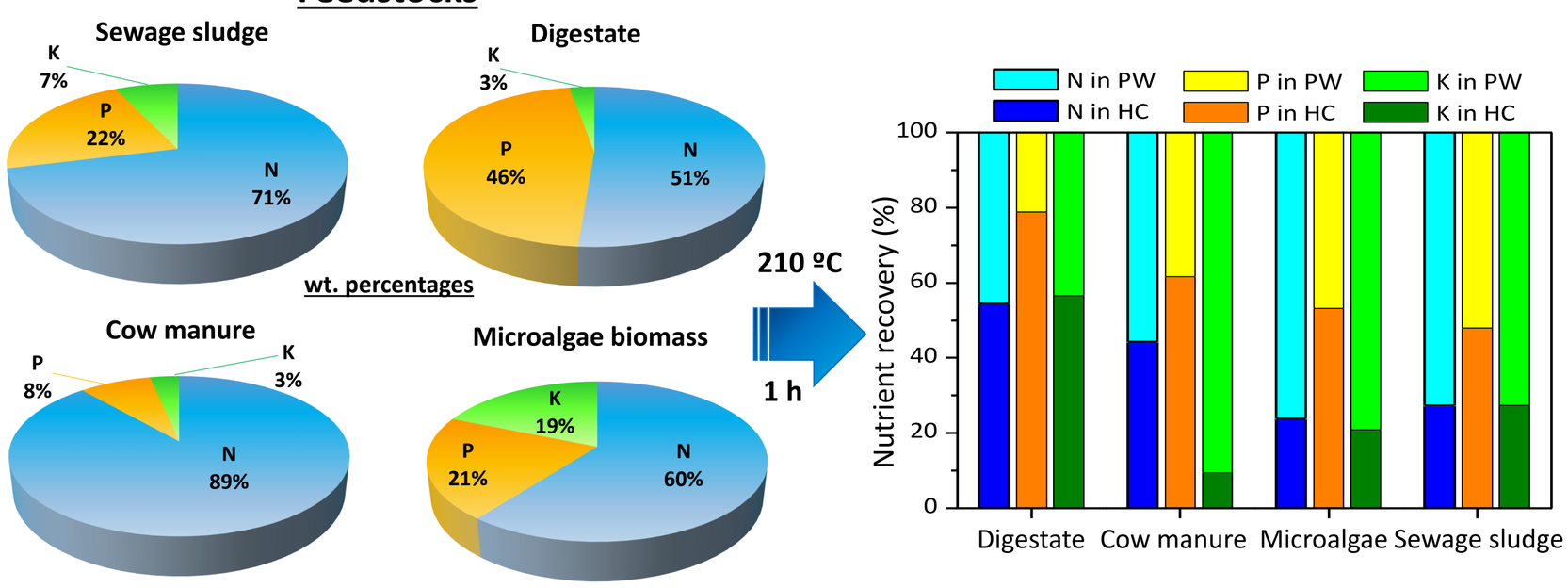
Characterization of hydrochars

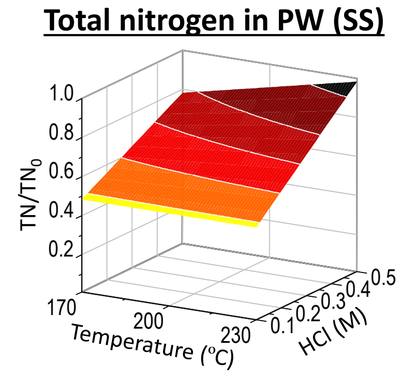
Residues	Volatile Matter (%)	Ash (%)	C (%)	N (%)	S (%)	HHV (MJ/kg)	Hydrochar yield (%)
Sewage sludge	65.4	19.7	43.1	4.6	0.2	21.6	40.0
Digestate	42.5	38.6	31.8	4.1	0.9	14.9	67.8
Cow manure	58.2	24.2	44.8	2.1	0.1	19.0	57.0
Microalgae biomass	40.4	39.5	41.8	3.7	0.2	18.6	37.6

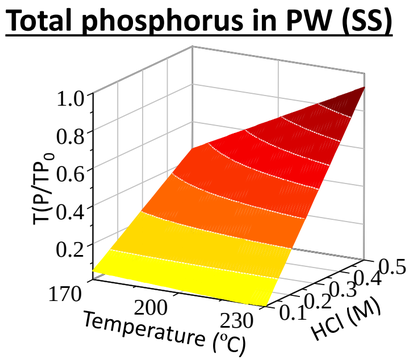


Nutrient recovery

Temperature and reaction time have a critical role in nutrient recovery from PW. Also, pH has a high relevance for phosphorus leaching. The addition of strong acids along HTC process can increase the recovery of phosphorous and nitrogen in the PW.





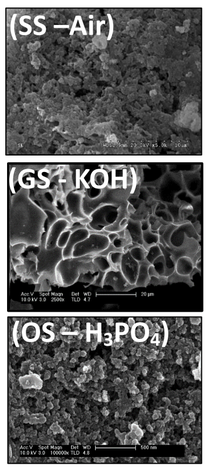


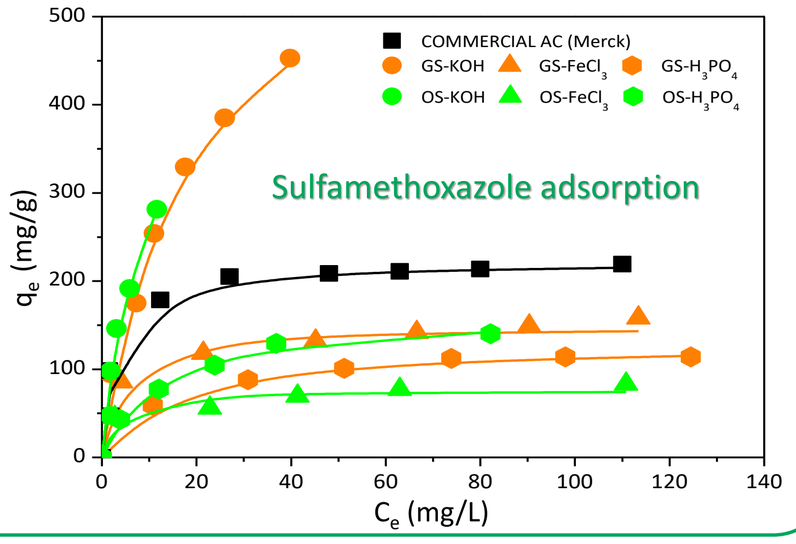
Production of hydrochar-based activated carbon

Hydrothermal carbonization of waste biomass is a promising step in the production of cost-effective activated carbon by physical (air) and chemical activation using KOH, $FeCl_3$ and H_3PO_4 as activating agents.

Biomass	Activation (Activating agent / T (°C))	A_{BET} (m^2/g)	Mesoporous volume (cm^3/g)
Sewage sludge (SS)	Air / 325	99	0.01
Grape seeds (GS)*	KOH / 750	2194	0.05
	$FeCl_3$ / 750	417	0.02
	H_3PO_4 / 500	596	0.21
Olive stones (OS)*	KOH / 750	2122	0.14
	$FeCl_3$ / 750	383	0.07
	H_3PO_4 / 500	1154	0.20

*Activated agent to hydrochar ratio (3:1)





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