Hydrothermal treatment of waste activated sludge and food waste: a circular economy approach to improve resource recovery In wastewater treatment plant

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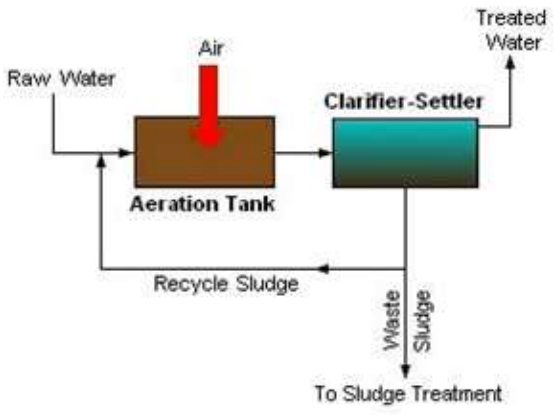
15th Specialized Conference on
Small Water & Wastewater Systems

7th Specialized Conference on
Resources Oriented Sanitation

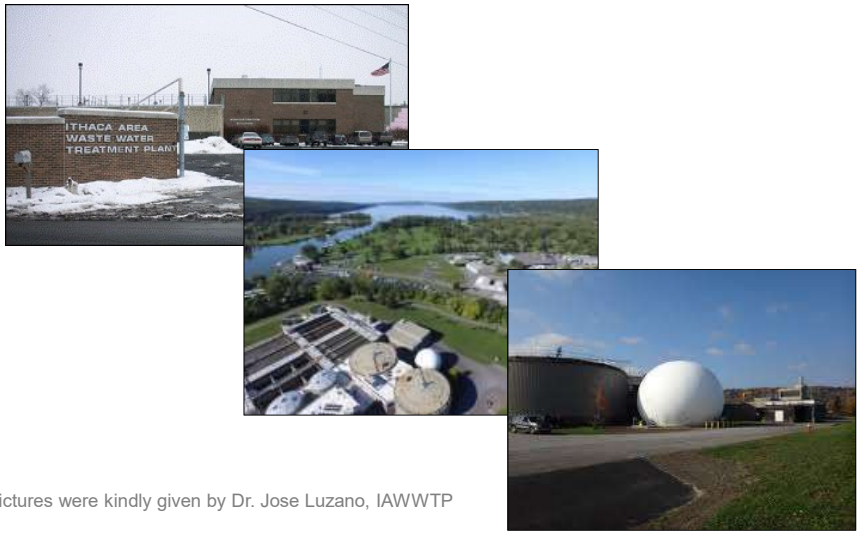
IWA the international water association

Activated sludge process



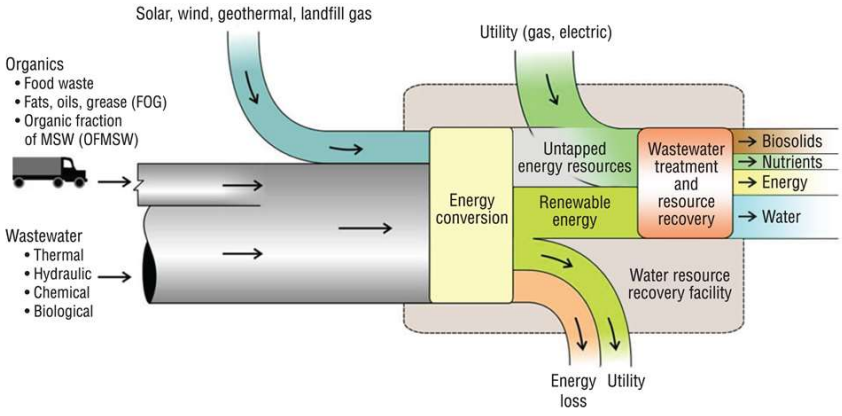
Source: Activated Sludge Process, IWA Publishing

Ithaca Area Wastewater Treatment Plant



Pictures were kindly given by Dr. Jose Luzano, IAWWTP

Co-digestion approach in WWTP



Source: BioCycle August 2014, Vol. 55, No. 7, p. 45

Motivation: Zero Waste

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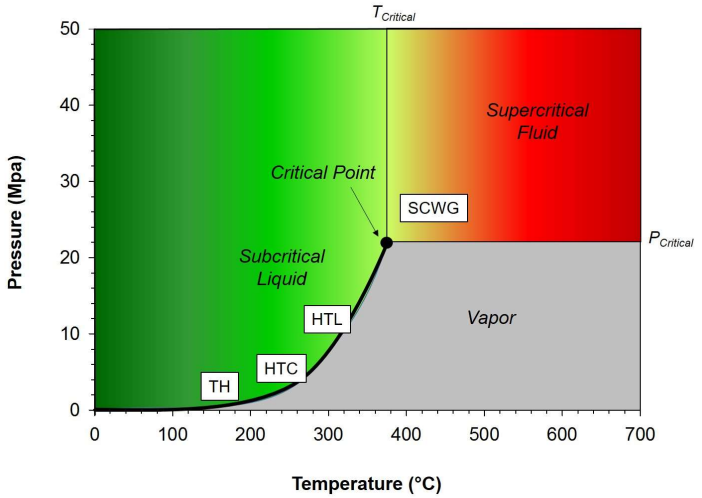
Motivation: Zero Waste

- The USA generated ~14 MT of wastewater sludge per year of which half was currently not being beneficially utilized.
- Anaerobic digestion (AD) of primary sludge to produce biogas is a popular method.
- Food waste is an additional source of revenue for WWTP and a good feedstock for AD.
- The digested sludge is commonly sent to the landfill after being dried which can cause environmental burdens and be costly.
- Hydrothermally treating the digested sludge may produce additional valuable product(s).
- Small amount (if any) of solids have to be sent to the landfill.

Hydrothermal biomass conversion



Angenent, L.T., Usack, J.G., Xu, J., Hafenbradl, D., Posmanik, R., Tester, J.W., 2018. Bioresour. Technol. 247, 1085–1094.

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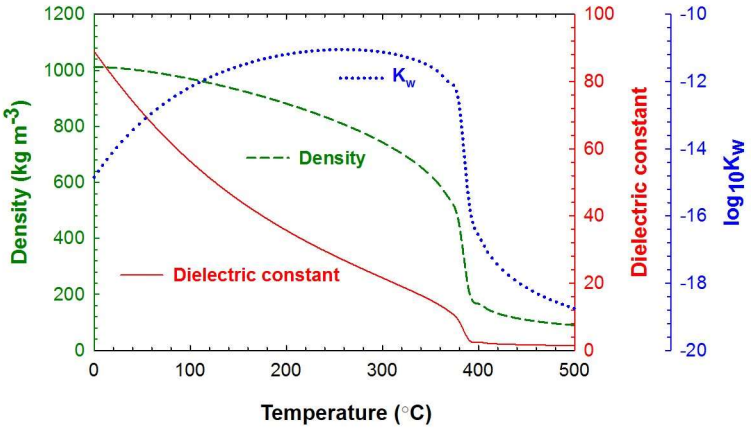

- Drastic drop in **dielectric constant** and **water density** with the increase of the **ionic product** near critical conditions.
- A good alternative to dissolve, hydrolyze and fractionate biomass.

Angenent, L.T., Usack, J.G., Xu, J., Hafenbradl, D., Posmanik, R., Tester, J.W., 2018. Bioresour. Technol. 247, 1085–1094.

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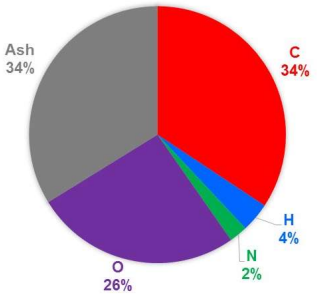
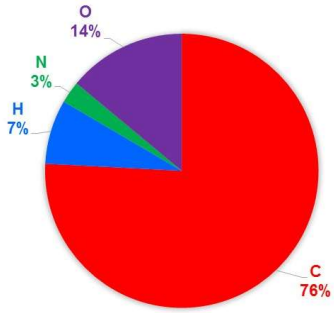
More carbon – Less oxygen

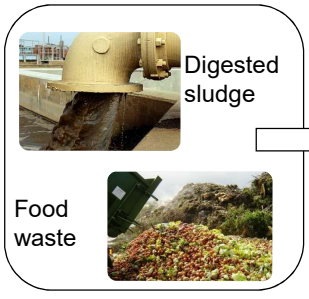


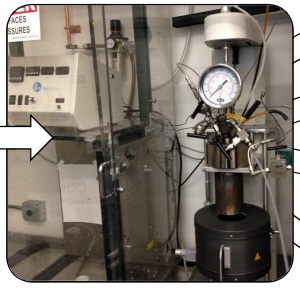


HTL allows fast conversion of organic carbon into bio-crude oil and other co-products

BIOMASS

HTL





Gas

Aqueous phase

Crude oil

Hydro char

5–60 minutes
200–350 ºC
2–20 MPa

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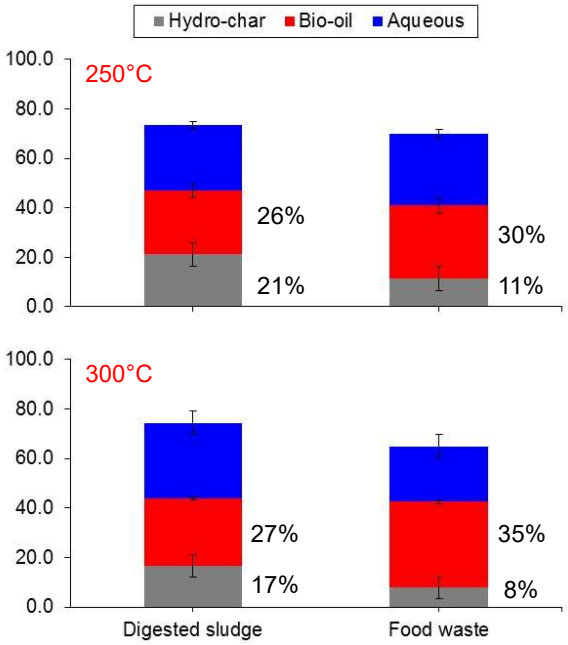
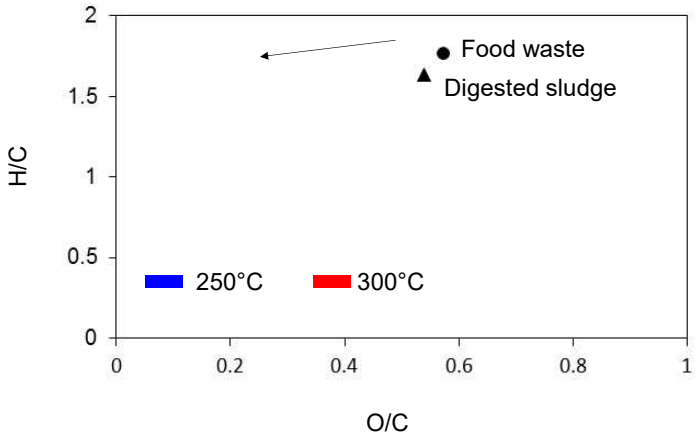
Carbon mass balance

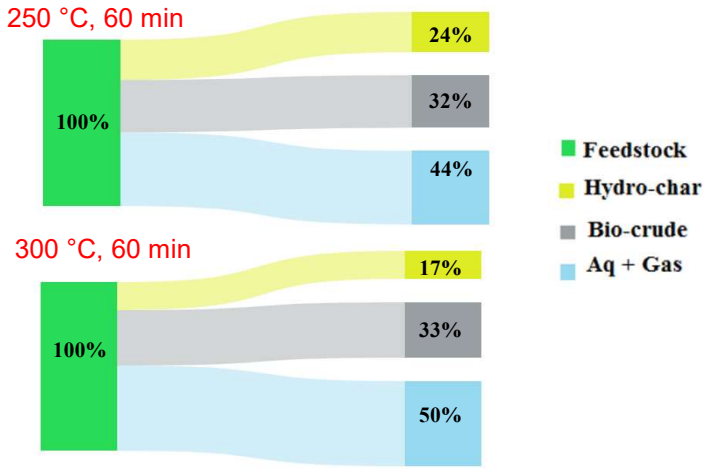
Higher T favors oil production but only from food waste.



HTL produces low-oxygen bio-crude oil regardless the temperature or feedstock

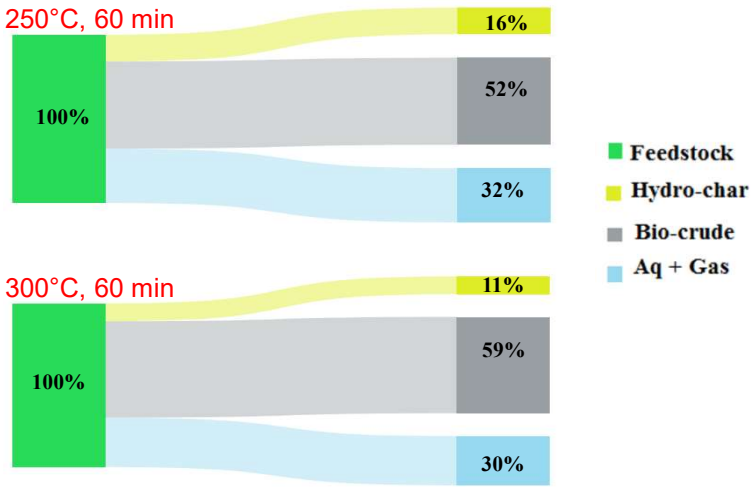


Energy balance: Digested sludge



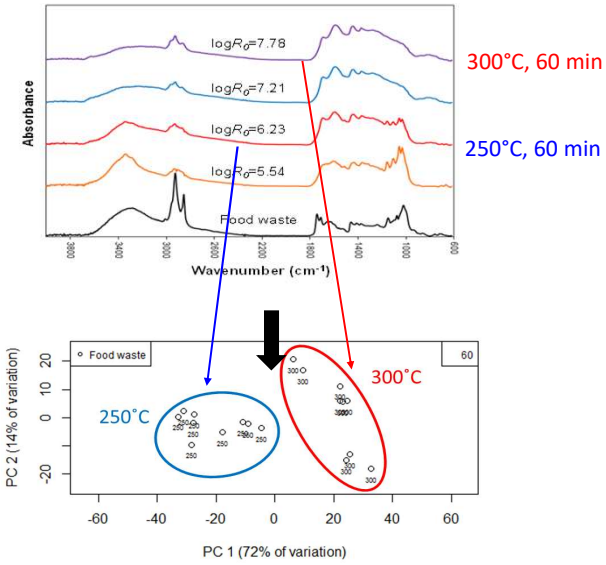
No energetic gain by higher temperature process

Energy balance: Food waste

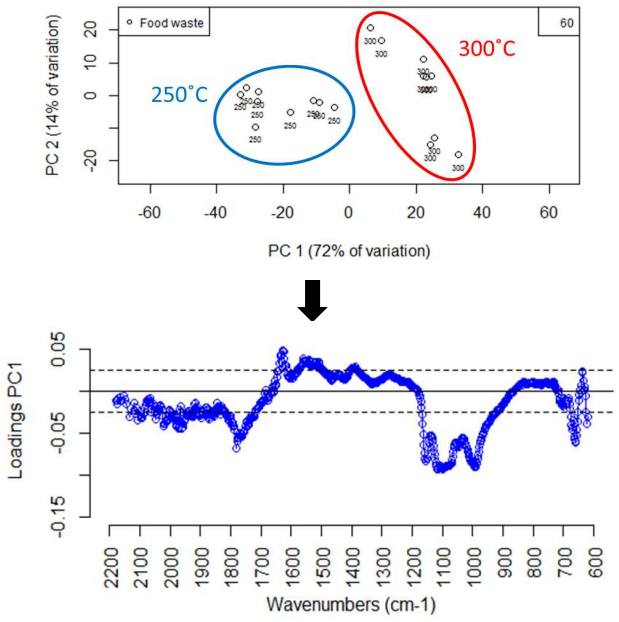


Total energy return is higher for higher T, due to higher oil production

How to use FTIR-PCA data to learn about different mechanisms during HTL



Cantero-Tubilla, B., Cantero, D.A., Martinez, C.M., Tester, J.W., Walker, L.P., Posmanik, R., 2018.. J. Supercrit. Fluids 133, 665–673.



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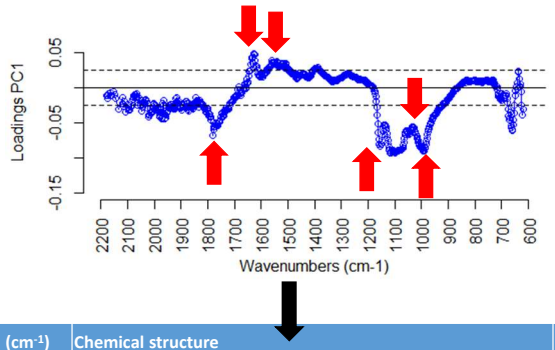

Wavenumber (cm^{-1})	Chemical structure	References
1780	C=O stretch	[5]
1630	Extractable carbonyl compounds formed from hemicelluloses	[12]
1510	Aromatic skeletal vibrations (lignin)	[17], [18]
1386	C-O stretching alcohols	[20]
1160	C-O-C asymmetrical stretching (hemicellulose and cellulose)	[15] [25]
1083	C-O stretching secondary alcohol	[28]
990	C-O valence vibration and ring stretch (cellulose)	[15] [1]

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Summary

- Hydrothermal technology can be integrated in WWTP to maximize resource recovery and energy return.
- Hydrothermal technology found to be better for food waste feedstock rather than digested sludge.
- FTIR-PCA data can be simply used to search for dominant chemical pathways along the process.
- Full life-cycle and economic assessment should be obtained prior next development stage.

Thank you!

Cornell University
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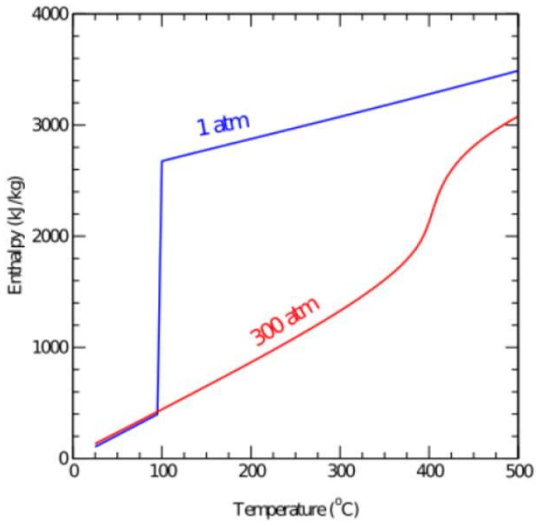
Enthalpy of water vs. Temp. at 1 and 300 atm



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