Supporting Information;

Comparative Study on the Continuous Flow Hydrothermal Liquefaction of Various Wet-Waste Feedstock Types

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EXPERIMENTAL

Reactor design and operation

The HTL runs in this study were conducted using one of two similar reactor setups, the process flow diagrams for which are described in Figure S1. The configuration and operation of the HTL system were conducted similarly to that previously reported by PNNL.[1]

Depending on the viscosity and odor of the feed material, it was contained in either a stirring tank, open vessel, or dispensed from piston tanks pressurized to 20 MPa (Configuration A, Figure S1). From here the feed material was fed to the reactor system using a 500 mL high-pressure metering syringe pump (ISCO). The ISCO pump delivered the feed material at a consistent rate to an oil-jacketed, tube-in-tube preheater. The feed material then continued to the plug flow reactor (PFR), which consisted of a second oil-jacketed, tube-in-tube reactor, where the primary conversion reaction occurred. The preheater reactor was set to a temperature of 325 °C and the PFR was set to 350 °C, for all HTL experiments. After passing through the PFR, the converted material entered a heated filter vessel, through which the residual solids are continuously blown down and collected in the blowdown pot for later quantitation and characterization. The filtered flow was then cooled by passing it through a finned-tube convection heat exchanger, reducing the flow temperature to 40 to 70 °C. The pressure was reduced using a back pressure regulator. The cooled, two-phase liquid flow then entered one of two parallel, N_2 pressurized vessels for collection. Once collected, the biphasic product was transferred to a large separatory funnel to separate the aqueous phase from the oil and to allow for gravimetric quantitation and subsequent analysis. The gaseous product phase continued through the reactor system through the main back pressure regulator, where its flow was quantitated using a wet test meter (WTM). A sample of this effluent was directed to an online gas chromatograph (GC), where it was analyzed for its H_2S, light hydrocarbon, and permanent gases content. This sampling and analysis process occurred every 4 min throughout the entirety of the HTL run.

The alternative system configuration (Configuration B, Figure S1) varies from the standard setup through the use of an additional Inconel continuous stirred tank reactor (CSTR). The CSTR is heated to the target reaction temperature of 350 °C, and immediately precedes the PFR.

HTL feed acquisition and characterization

Feedstock samples were obtained from a range of different commercial and municipal sources throughout the US. The details of the specific feed type used in each wet-waste continuous flow HTL run are listed in Table S1. The materials were characterized via elemental and proximate analysis techniques to determine their elemental composition, as well as their ash, carbohydrate, protein, fat, and fatty acid methyl ester (FAME) content.

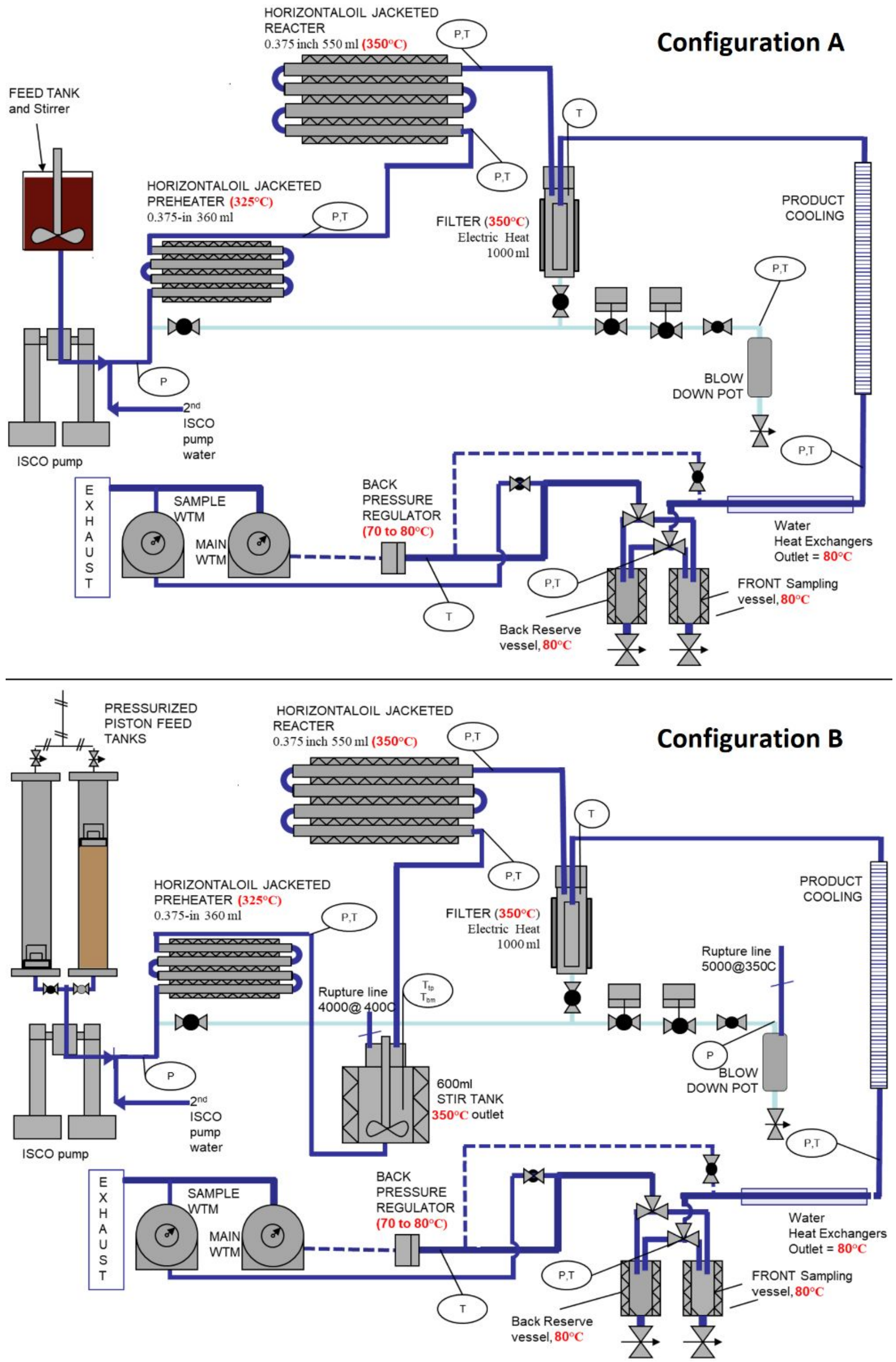

Figure 1 - Process flow diagram of the bench-scale HTL reactor system setup in Configuration A and Configuration B

Analytical methods

A comprehensive set of analyses was performed to quantitatively characterize the feed and product fractions, such that an accurate mass balance and comparative analysis could be performed.

Elemental analyses of the feed, liquid, and solid phases were performed using ASTM D5291/D5373 (for carbon, hydrogen, and nitrogen), ASTM D5373, modified (for oxygen), and ASTM D1552/D4239 (for sulfur). For the biocrude samples, moisture content was determined by the Karl Fischer technique using Method ASTM D6869, total acid number (TAN) was measured following ASTM D3339, the percentage of filtered oil solids was measured using ASTM D7579-09, and density and kinematic viscosity measurements were performed using an Anton Paar SVM3000 Stabinger Viscometer (and presented at a temperature of 40 °C). Density measurements for feedstock samples were calculated either gravimetrically using a graduated centrifuge cone, or through the use of a pycnometer. Analyses for ash, dry solid content, and product weight were performed gravimetrically. An Inficon Model 3000 Micro Gas Chromatograph (GC) with a thermal conductivity detector (TCD) was used for the online analysis of the HTL process gas stream. A multicolumn setup was employed, using mol sieve, PLOTU, alumina, and stabilwax columns. Ar and He were used as the carrier gasses. Values for pH in both the feed and aqueous samples were measured via a pH meter. Analyses for ash, dry solid content, and product weight were performed gravimetrically.

Proximate analysis of the feed was conducted using several methods. Fat content was determined after acid hydrolysis and ether extraction using the AOAC digest/gravimetric method. Protein content was determined by combustion using methods FSIS CLG-PRO4.03, AOAC 992.15, and 992.23. Carbohydrate content was determined via the AOAC 986.25 calculation method. FAME content was determined via GC/FID using methods AOCS Ce 2-66 and Ce 1b-89.

Response variables and mass-balance

The focal part of this study was determining the mass and carbon yield that was obtained in the biocrude product and investigating how this value was impacted by feed type. An accurate mass balance procedure was therefore pivotal to the work, which included quantification of the quantity and rate of carbon fed into the system, along with each of the product phases (outputs) obtained. This can be simplified as the feed (input), and the; biocrude, solids, gaseous, and aqueous phases (outputs). Provided that these product phases account for the entire carbon input and output across the system and that their rate of consumption/production can be accurately determined, an accurate carbon mass balance can be obtained for the process. The experimental response variables and equations defined in this study are listed in Table S1.

Samples of biocrude and aqueous phase were obtained by collecting multiple set-aside samples (typically 800 to 1200 mL, each) from the reactor system at pre-determined sampling times during steady-state conditions. This allowed for multiple large samples to be obtained throughout a single campaign, improving the accuracy of the analyses and the subsequent mass balance. The precise sampling time for each specific set-aside was calculated using the volume of the feed at the start and end of sampling (fv_{start} and fv_{end}), and the rate at which it was fed (fr) (Equation 1). The biocrude and aqueous phases were obtained as a two-phase liquid output, which was separated for quantitation and analysis via liquid-liquid separation. The solids accumulation over the total run time (the time period from which the feed begins and ends being pumped into the reactor system, t_{run}), and the rate of production (pr_s), were determined by dividing the total mass obtained (m_{bd}) by the time (t_{run}) (Equation 7). The relative quantity of solids produced during a set aside

(m_s) was then determined by multiplying the calculated rate by the sampling time (t_{samp}) (Equation 4). Similarly, the quantity of gas produced during each set aside (m_g) was determined by combining the sampling time (t_{samp}) with the production rate of the gaseous phase (pr_g) (Equation 6). The gas production rate was determined using the data obtained from the wet test meter (L.h^{-1}), in combination with the ideal gas law and the carbon content of the gas (as determined by online gas-chromatography analysis) (Equation 8).

The solids and ash content of the feed, biocrude, and solids, were determined by drying samples to constant weight in an oven at 105 °C, and via ashing in a muffle furnace, respectively. The carbon content of the feed (C_f), biocrude (C_b), solids (C_s), and aqueous phase (C_a) were all determined via elemental analysis.

The carbon yield from each specific product phase was determined using the mass of carbon in that phase (calculated using its mass and carbon content), and the mass of carbon fed into the system during that specific sampling time. This variable was defined as the sample feed mass (m_f), and was calculated using the sampling time, feed density (fd), and feed rate (fr) (Equation 2). The sum of the carbon yield for the biocrude (CY_b), solids (CY_b), gaseous (CY_b), and aqueous phase (CY_b), gives the total carbon yield (CY_t), which has a theoretical value of 100%. To account for experimental variation between the different HTL runs, the theoretical yield was used to normalize the carbon yield data, e.g., total carbon yield (CY_t) was set equal to 100% (Equation 21 to 25).

Mass balance data was also calculated for each of the product fractions as a wt% of the sample feed mass (m_f), on a dry ash-free (daf) material basis and a wet feed basis. This data is useful for comparing feedstock and process conditions concerning the efficiency of a proposed HTL biorefinery. Given that the quantity of daf material present in the aqueous phase is difficult to accurately quantify due to the presence of volatile organics, this data was not approximated. As a result, the yield for the aqueous phase (on daf basis), was determined as the remainder of the unaccounted-for mass balance.

Experimental plan and statistical analysis

In each HTL run, a single feed type, and, in most instances, a single set of processing conditions, is referred to as a steady-state condition. In six runs, two different steady-states were tested, wherein the system was stabilized at the second set of specific feed and operating conditions before sampling and data collection. Because the primary goal of this study was to investigate the impact of different feedstock types on the yield and composition of the product streams, reactor conditions were held as constant as possible across the range of experiments performed.

The range of variables in the dataset was classified into four main classes: feedstock and process characteristics (input variables), and mass balance and biocrude characteristics (outcome variables). Feedstock characteristics relate directly to the feedstock material and are independent of HTL process variables such as reactor conditions and feed preparation (i.e. total solids variation or the inclusion of additives), and are expressed as a weight percentage of the material on a dry basis. Process characteristics included all reactor conditions and run variables, as well as the characteristics of the feed material as fed into the reactor (and are hence expressed as a weight percentage on a wet basis). The mass balance characteristics are the range of results obtained and were determined on carbon basis (C%), normalized carbon basis (C%), daf feed basis (daf wt%), and wet feed basis (wt%). Finally, biocrude characteristics were data pertaining to the produced biocrude material. This information is summarized in Table S2. A range of statistical analyses was conducted on the dataset using the JMP V16.0 software package. This involved evaluating the impact of individual input variables (such as the carbon content of the feedstock, the reactor feed rate, etc.), as well as more complex multivariate modeling, on key performance indicator outputs (such as biocrude yield and HHV). For all regression models produced and evaluated in this study, coefficients with large p-values (>0.05) were excluded from the model formulation.

It should be emphasized that this study was primarily an investigation into the effect of feedstock type on biocrude yield and quality and not an evaluation of reactor conditions. Even though many key process variables were recorded and analyzed in this study, these variables were often maintained within relatively narrow ranges. Such an approach was taken because optimized ranges for these conditions have been previously identified through the work of PNNL, and other researchers, in continuous flow wet-waste HTL processing. As a result, it is expected that certain process variables which are important to the HTL process (such as feed density, pH, run temperature, etc.), may not be identified through statistical analysis of this dataset as being highly significant.

Table S1 - Feed type and source utilized in each wet-waste continuous flow HTL run

Run	**Feed type**	**Feed source**
WW-2	Fermentation waste (Grape pomace)	Grape Pomace of Cabernet Sauvignon from Columbia Crest Winery (Washington)
WW-5	Fermentation waste (IPA grain)	Extracted cracked grains from the production of Ice Harbor IPA collected at the Ice Harbor Brewery (Washington)
WW-6	Sludge	Equal parts mixture of primary and secondary sludge from the Great Lakes Water Authority (Michigan)
WW-9	Sludge	Equal parts mixture of primary and secondary sludge containing approximately 6 wt% lime addition from Contra Costa Central Sanitary District (California)
WW-10	Blend	80% sludge and 20% FOG (fats, oils & grease) blend from Contra Costa Central Sanitary District (California)
WW-14	Biosolids	Biosolids (post anaerobic digestion treatment) from Hornsby Bend (Texas), provide by Aloviam (Texas).
WW-15	Manure (Swine)	Swine manure from Purdue University (Indiana)
WW-17	Sludge	Equal parts mixture of primary and secondary sludge from Contra Costa Central Sanitary District (California)
WW-18	FOG-rich blend	A 53:47 weight ratio (on a dry basis) of fermentation residue from Liberty Cellulosic Ethanol Plant (Iowa) and autoclaved decanted scum from Contra Costa Central Sanitary District (California)
WW-19	Manure (Bovine)	Bovine manure from Washington State University (Washington)
WW-20	Food waste	Food waste from Coyote Ridge Correctional Center (Washington)
WW-21	Food waste	Food waste from Ghost Warrior and Courage Inn Restaurants from the United States Air Force Joint Base Lewis–McChord airbase (Washington)
WW-22	Blend	A 57:42:2 (wt%) blend of sludge, food waste, and FOG. The sludge and FOG were obtained from Great Lakes Water Authority (Detroit), and the food waste was obtained from Coyote Ridge Correctional Center (Washington)
WW-23	Food waste	Food waste from Waste Management, Engineered BioSlurry (Boston)

Table S2 – Experimental response variables, their definitions, and the methods used in their determination

Response variable	**Method**
t_{samp} $-$ *sampling time* (h)	Equation 1
$fv_{start} -$ *feed volume at sampling start point* (L)	ISCO pump
fv_{end} $-$ *feed volume at sampling end point* (L)	ISCO pump
$fr -$ *feed rate* $(L.h^{-1})$	ISCO pump
$fd -$ *feed density* $(g.L^{-1})$	Gravimetric/volumetric
$fs -$ *feed dry solids content* $(wt\%)$	Drying/gravimetric
$fa -$ *feed ash cotent of dry solids* $(wt\%)$	Ashing/gravimetric
$Ss -$ *solids phase dry solids content* $(wt\%)$	Drying/gravimetric
$Sa -$ *solids phase ash cotent of dry solids* $(wt\%)$	Ashing/gravimetric
$m_f -$ *sample feed mass* (g)	Equation 2
$daf\ m_f -$ *sample feed mass* $(daf\ g)$	Equation 3
$m_b -$ *biocrude mass* (g)	Gravimetric
$m_s -$ *solids phase mass* (g)	Equation 4
$daf\ m_s -$ *solids phase mass* $(daf\ g)$	Equation 5
$m_g -$ *gaseous phase mass* (g)	Wet test meter, GC & Equation 6
$m_a -$ *aqueous phase mass* (g)	Gravimetric
m_{bd} – *cumulative mass of blowdown solids* (g)	Gravimetric
$t_{run} -$ *total feed time* (h)	Observation & ISCO pump
$gf -$ *flow rate of gaseous product stream* $(L.h^{-1})$	Wet test meter
$C_f -$ *carbon content of the feed* $(wt\%)$	Elemental analysis
$C_b -$ *carbon content of the biocrude* $(wt\%)$	Elemental analysis
$C_s -$ *carbon content of the solids phase* $(wt\%)$	Elemental analysis
$C_g -$ *carbon content of the gaseous phase* $(wt\%)$	GC
$C_a -$ *carbon content of the aqueous phase* $(wt\%)$	Elemental analysis
$pr_s -$ *production rate of solids phase* $(g.h^{-1})$	Equation 7
$pr_g -$ *production rate of gaseous phase* $(g.h^{-1})$	Equation 8
$daf\ Y_b -$ *yield of biocrude* $(daf\ wt\%)$	Equation 9
$daf\ Y_s -$ *yield of solids phase* $(daf\ wt\%)$	Equation 10
$daf\ Y_g -$ *yield of gaseous phase* $(daf\ wt\%)$	Equation 11
$daf\ Y_a -$ *yield of aqueous phase* $(daf\ wt\%)$	Equation 12
$Y_b -$ *yield of biocrude* $(wt\%)$	Equation 13
$Y_s -$ *yield of solids phase* $(wt\%)$	Equation 14
$Y_g -$ *yield of gaseous phase* $(wt\%)$	Equation 15
$Y_a -$ *yield of aqueous phase* $(wt\%)$	Equation 16
$CY_b -$ *carbon yield of biocrude phase* $(C\%)$	Equation 17
$CY_s -$ *carbon yield of solids phase* $(C\%)$	Equation 18
$CY_g -$ *carbon yield of gaseous phase* $(C\%)$	Equation 19
$CY_a -$ *carbon yield of aqueous phase* $(C\%)$	Equation 20
$CY_t -$ *total cumulative carbon yield* $(C\%)$	Equation 21
$CY_b(N) -$ *normalized carbon yield of biocrude* $(C\%)$	Equation 22
$CY_s(N) -$ *normalized carbon yield of solids phase* $(C\%)$	Equation 23
$CY_g(N) -$ *normalized carbon yield of gaseous phase* $(C\%)$	Equation 24
$CY_a(N) -$ *normalized carbon yield of aqueous phase* $(C\%)$	Equation 25

The equations defined for use in this study are described below:

$$t_{samp} = \frac{fv_{end} - fv_{start}}{fr} \quad (h) \qquad Equation\ 1$$

$$m_f = t_{samp} \times fr \times fd \times 1000 \quad (\mathrm{g}) \qquad Equation\ 2$$

$$daf\ m_f = m_f \times fs \times (1 - fa) \quad (daf\ g) \quad Equation\ 3$$

$$m_s = t_{samp} \times pr_s \qquad (g) \qquad Equation\ 4$$

$$daf\ m_s = m_s \times Ss \times (1 - Sa) \quad (daf\ g) \quad Equation\ 5$$

$$m_g = t_{samp} \times pr_g \quad (\mathrm{g}) \qquad Equation\ 6$$

$$pr_s = \frac{m_{bd}}{t_{run}} \quad (g) \qquad Equation\ 7$$

$$pr_g = \frac{gf}{RT} \times \mathrm{C}_g \times \mathrm{M}_C \quad (\mathrm{g.h^{-1}}) \qquad Equation\ 8$$

where; $\mathrm{R} = 0.08206 \frac{\mathrm{L.atm}}{K.mol}$ $and\ T = 293\ K\ and\ C_g =\ as\ determined\ by\ GC\ analysis$ (%)

$$daf\ Y_b = \frac{m_b}{daf\ m_f} \times 100 \quad (\text{daf wt\%}) \qquad Equation\ 9$$

$$daf\ Y_s = \frac{daf\ m_s}{daf\ m_f} \times 100 \quad (\text{daf wt\%}) \qquad Equation\ 10$$

$$Y_g = \frac{m_g}{daf\ m_f} \times 100 \quad (\text{daf wt\%}) \qquad Equation\ 11$$

$$Y_a = 100 - (daf\ m_b + daf\ m_s + daf\ m_g) \quad (\text{daf wt\%}) \qquad Equation\ 12$$

$$Y_b = \frac{m_b}{m_f} \times 100 \quad (\text{wt\%}) \qquad Equation\ 13$$

$$Y_s = \frac{m_s}{m_f} \times 100 \quad (\text{wt\%}) \qquad Equation\ 14$$

$$Y_g = \frac{m_g}{m_f} \times 100 \quad (\text{wt\%}) \qquad Equation\ 15$$

$$Y_a = \frac{m_a}{m_f} \times 100 \quad (\text{wt\%}) \qquad Equation\ 16$$

$$CY_b = \frac{m_b \times C_b}{m_f \times C_f} \times 100 \quad (\%) \qquad Equation\ 17$$

$$CY_s = \frac{m_s \times C_s}{m_f \times C_f} \times 100 \quad (\%) \qquad Equation\ 18$$

$$CY_g = \frac{m_g \times C_g}{m_f \times C_f} \times 100 \quad (\%) \qquad Equation\ 19$$

$$CY_a = \frac{m_a \times C_a}{m_f \times C_f} \times 100 \quad (\%) \qquad Equation\ 20$$

$$CY_t = CY_b + CY_s + CY_g + CY_a\ (\%) \quad Equation\ 21$$

$$CY_b(N) = \frac{100}{CY_t} \times CY_b \quad (\%) \qquad Equation\ 22$$

$$CY_s(N) = \frac{100}{CY_t} \times CY_s \quad (\%) \qquad Equation\ 23$$

$$CY_g(N) = \frac{100}{CY_t} \times CY_g \quad (\%) \qquad Equation\ 24$$

$$CY_a(N) = \frac{100}{CY_t} \times CY_a \quad (\%) \qquad Equation\ 25$$

Note: these values are calculated by normalizing the CY_t *and closing the mass balance such that* $CY_b(N) + CY_s(N) + CY_g(N) + CY_a(N) = 100\%$

Table S3 – List of dataset variables grouped by class

Variable class	Variable			
Feedstock	Feed type	Feed HHV (dry) (MJ/kg)	Feed C content (dry) (wt%)	Feed H content (dry) (wt%)
	Feed N content (dry) (wt%)	Feed O content (dry) (wt%)	Feed S content (dry) (wt%)	Feed carbohydrates content (dry) (wt%)
	Feed fat content (dry) (wt%)	Feed protein content (dry) (wt%)	Feed ash content (dry) (wt%)	
Process	Feed Rate (L/h)	Feed density (g/mL)	Na_2CO_3 added?	CSTR used?
	Feed rate (kg/h)	Feed pH	LHSV (L/L/h)	Run temperature (°C)
	Hours on stream (h)	Feed solids content (wt%)	Feed ash content (wt%)	Ash-free solids in feed (wt%)
	Feed C content (wt%)	Feed H content (wt%)	Feed N content (wt%)	Feed O content (wt%)
	Feed S content (wt%)	Feed carbohydrates content (wt%)	Feed fat content (wt%)	Feed protein content (wt%)
	Feed FAMES content (wt%)	Feed carbs:protein (wt%)	Feed heteroatom content (sum) (wt%)	Feed heteroatom content (dif) (wt%)
Mass balance	Biocrude mass yield (wt%)	Solids mass yield (wt%)	Gas mass yield (wt%)	Aqueous mass yield (wt%)
	Total mass yield (wt%)	Biocrude production rate (g/h)	Biocrude mass yield (daf wt%)	Solids mass yield (daf wt%)
	Gas mas yield (daf wt%)	Aqueous mass yield (wt%)	Biocrude yield (C%)	Solids yield (C%)
	Gas yield (C%)	Aqueous yield (C%)	Total yield (C%)	Biocrude yield (normalized) (C%)
	Solids yield (normalized) (C%)	Gas yield (normalized) (C%)	Aqueous yield (normalized) (C%)	
Biocrude	Biocrude C content (wt%)	Biocrude H content (wt%)	Biocrude H:C (wt%)	Biocrude O content (wt%)
	Biocrude N content (wt%)	Biocrude S content (wt%)	Biocrude HHV (MJ/kg)	Biocrude TAN (mgKOH/g oil)
	Biocrude density (at 40 °C) (g/mL)	Biocrude viscosity (at 40 °C) (cSt)	Biocrude moisture content (wt%)	Biocrude ash content (dry) (wt%)
	Biocrude filterable solids content (dry) (wt%)			

RESULTS

Table S4 – Listing of feedstock and process variables for each of the wet waste HTL runs conducted in this study

		Feedstock variables											Process variables																							
Run	Set aside	Feed type	Feed HHV (dry) (MJ/kg)	Feed C content (dry) (wt%)	Feed H content (dry) (wt%)	Feed N content (dry) (wt%)	Feed O content (dry) (wt%)	Feed S content (dry) (wt%)	Feed carbohydrates content (dry) (wt%)	Feed fat content (dry) (wt%)	Feed protein content (dry) (wt%)	Feed ash content (dry) (wt%)	Feed Rate (L/h)	Feed density (g/mL)	Na_2CO_3 added?	CSTR used?	Feed rate (kg/h)	Feed pH	LHSV (L/L/h)	Run temperature (°C)	Hours on stream (h)	Feed solids content (wt%)	Feed ash content (wt%)	Ash-free solids in feed (wt%)	Feed C content (wt%)	Feed H content (wt%)	Feed N content (wt%)	Feed O content (wt%)	Feed S content (wt%)	Feed carbohydrates content (wt%)	Feed fat content (wt%)	Feed protein content (wt%)	Feed FAMES content (wt%)	Feed carbs:protein (wt%)	Feed heteroatom content (sum) (wt%)	Feed heteroatom content (dif) (wt%)
2-1	1	FM (Grape pomace)	19.907	48.53	5.40	1.53	30.4	0.12	-	-	-	11.4	1.5	1.050	Y	Y	1.6	7.1	2.1	339	3.3	16.8	1.9	14.9	8.2	10.2	0.257	79.1	0.020	-	-	-	-	-	79.3	81.7
2-1	2	FM (Grape pomace)	19.907	48.53	5.40	1.53	30.4	0.12	-	-	-	11.4	1.5	1.050	Y	Y	1.6	7.1	2.1	339	3.3	16.8	1.9	14.9	8.2	10.2	0.257	79.1	0.0202	-	-	-	-	-	79.3	81.7
2-1	3	FM (Grape pomace)	19.907	48.53	5.40	1.53	30.4	0.12	-	-	-	11.4	1.5	1.050	Y	Y	1.6	7.1	2.1	339	3.3	16.8	1.9	14.9	8.2	10.2	0.257	79.1	0.0202	-	-	-	-	-	79.3	81.7
2-1	4	FM (Grape pomace)	19.907	48.53	5.40	1.53	30.4	0.12	-	-	-	11.4	4.0	1.034	Y	N	4.1	6.1	8.0	331	0.7	13.6	0.8	12.8	8.2	10.2	0.257	79.1	0.0202	-	-	-	-	-	79.3	81.7
2-1	5	FM (Grape pomace)	19.907	48.53	5.40	1.53	30.4	0.12	-	-	-	11.4	4.0	1.034	Y	N	4.1	6.1	8.0	331	0.7	13.6	0.8	12.8	8.2	10.2	0.257	79.1	0.0202	-	-	-	-	-	79.3	81.7
5-1	1	FM (IPA grain)	20.154	47.38	6.37	3.45	36.2	0.24	67.0	9.05	20.4	5.8	2.0	1.065	N	Y	2.1	5.9	1.8	342	6.3	20.3	5.3	15.0	6.4	10.5	0.469	81.7	0.0326	9.1	1.2	2.8	1.0	3.3	82.2	83.1
5-1	2	FM (IPA grain)	20.154	47.38	6.37	3.45	36.2	0.24	67.0	9.05	20.4	5.8	2.0	1.065	N	Y	2.1	5.9	1.8	342	6.3	20.3	5.3	15.0	6.4	10.5	0.469	81.7	0.0326	9.1	1.2	2.8	1.0	3.3	82.2	83.1
6-1	1	Sludge	17.798	41.06	5.67	4.98	26.1	1.03	16.7	22.6	34.1	26.1	2.0	1.065	N	Y	2.1	5.9	1.8	342	6.3	20.3	5.3	15.0	8.3	10.0	1.011	76.1	0.2091	3.4	4.6	6.9	2.4	0.5	77.4	81.7
6-1	2	Sludge	17.798	41.06	5.67	4.98	26.1	1.03	16.7	22.6	34.1	26.1	4.0	1.065	N	Y	4.3	5.9	3.6	347	3.7	20.3	5.3	15.0	8.3	10.0	1.011	76.1	0.2091	3.4	4.6	6.9	2.4	0.5	77.4	81.7
6-1	3	Sludge	17.798	41.06	5.67	4.98	26.1	1.03	16.7	22.6	34.1	26.1	4.0	1.065	N	Y	4.3	5.9	3.6	347	3.7	20.3	5.3	15.0	8.3	10.0	1.011	76.1	0.2091	3.4	4.6	6.9	2.4	0.5	77.4	81.7
6-2	1	Sludge	17.798	41.06	5.67	4.98	26.1	1.03	16.7	22.6	34.1	26.1	4.0	1.065	N	Y	4.3	5.9	3.6	347	3.7	20.3	5.3	15.0	8.3	10.0	1.011	76.1	0.2091	3.4	4.6	6.9	2.4	0.5	77.4	81.7
6-2	2	Sludge	17.798	41.06	5.67	4.98	26.1	1.03	16.7	22.6	34.1	26.1	4.0	1.060	N	Y	4.2	5.9	3.6	346	10.0	17.4	2.9	14.5	8.3	10.0	1.011	76.1	0.2091	3.4	4.6	6.9	2.4	0.5	77.4	81.7
6-3	3	Sludge	17.798	41.06	5.67	4.98	26.1	1.03	16.7	22.6	34.1	26.1	4.0	1.060	N	Y	4.2	5.9	3.6	346	10.0	17.4	2.9	14.5	8.3	10.0	1.011	76.1	0.2091	3.4	4.6	6.9	2.4	0.5	77.4	81.7
9-1	1	Sludge	19.060	43.33	6.31	4.53	30.2	0.44	22.3	21.0	39.8	16.7	4.0	1.060	N	Y	4.2	5.9	3.6	346	10.0	17.4	2.9	14.5	7.5	10.3	0.788	78.7	0.0766	3.9	3.7	6.9	3.0	0.6	79.5	82.2
9-1	2	Sludge	19.060	43.33	6.31	4.53	30.2	0.44	22.3	21.0	39.8	16.7	4.0	1.060	N	Y	4.2	5.9	3.6	346	10.0	17.4	2.9	14.5	7.5	10.3	0.788	78.7	0.0766	3.9	3.7	6.9	3.0	0.6	79.5	82.2
9-1	3	Sludge	19.060	43.33	6.31	4.53	30.2	0.44	22.3	21.0	39.8	16.7	4.0	1.060	N	Y	4.2	5.9	3.6	346	10.0	17.4	2.9	14.5	7.5	10.3	0.788	78.7	0.0766	3.9	3.7	6.9	3.0	0.6	79.5	82.2
9-1	4	Sludge	19.060	43.33	6.31	4.53	30.2	0.44	22.3	21.0	39.8	16.7	4.1	1.052	N	Y	4.3	5.9	3.7	345	13.5	16.8	2.9	13.9	7.5	10.3	0.788	78.7	0.0766	3.9	3.7	6.9	3.0	0.6	79.5	82.2
9-1	5	Sludge	19.060	43.33	6.31	4.53	30.2	0.44	22.3	21.0	39.8	16.7	4.1	1.052	N	Y	4.3	5.9	3.7	345	13.5	16.8	2.9	13.9	7.5	10.3	0.788	78.7	0.0766	3.9	3.7	6.9	3.0	0.6	79.5	82.2
10-1	1	Blend	22.515	49.52	6.90	3.13	24.6	0.47	46.1	13.1	21.1	17.2	4.1	1.052	N	Y	4.3	5.9	3.7	345	13.5	16.8	2.9	13.9	8.3	10.4	0.526	78.1	0.0790	7.7	2.2	3.5	4.3	2.2	78.7	81.3
10-1	2	Blend	22.515	49.52	6.90	3.13	24.6	0.47	46.1	13.1	21.1	17.2	4.1	1.052	N	Y	4.3	5.9	3.7	345	13.5	16.8	2.9	13.9	8.3	10.4	0.526	78.1	0.0790	7.7	2.2	3.5	4.3	2.2	78.7	81.3
10-1	3	Blend	22.515	49.52	6.90	3.13	24.6	0.47	46.1	13.1	21.1	17.2	4.1	1.052	N	Y	4.3	5.9	3.7	345	13.5	16.8	2.9	13.9	8.3	10.4	0.526	78.1	0.0790	7.7	2.2	3.5	4.3	2.2	78.7	81.3
10-1	4	Blend	22.515	49.52	6.90	3.13	24.6	0.47	46.1	13.1	21.1	17.2	4.1	1.052	N	Y	4.3	5.9	3.7	345	13.5	16.8	2.9	13.9	8.3	10.4	0.526	78.1	0.0790	7.7	2.2	3.5	4.3	2.2	78.7	81.3
10-1	5	Blend	22.515	49.52	6.90	3.13	24.6	0.47	46.1	13.1	21.1	17.2	4.1	1.063	N	Y	4.3	7.7	3.6	343	10.0	16.7	5.3	11.3	8.3	10.4	0.526	78.1	0.0790	7.7	2.2	3.5	4.3	2.2	78.7	81.3
10-1	6	Blend	22.515	49.52	6.90	3.13	24.6	0.47	46.1	13.1	21.1	17.2	4.1	1.063	N	Y	4.3	7.7	3.6	343	10.0	16.7	5.3	11.3	8.3	10.4	0.526	78.1	0.0790	7.7	2.2	3.5	4.3	2.2	78.7	81.3
14-1	1	Biosolids	14.217	34.32	4.70	5.32	26.0	1.58	18.0	11.0	30.0	32.6	4.1	1.063	N	Y	4.3	7.7	3.6	343	10.0	16.7	5.3	11.3	5.7	10.0	0.888	78.4	0.2639	3.0	1.8	5.0	-	0.6	79.5	84.2
14-1	2	Biosolids	14.217	34.32	4.70	5.32	26.0	1.58	18.0	11.0	30.0	32.6	4.1	1.063	N	Y	4.3	7.7	3.6	343	10.0	16.7	5.3	11.3	5.7	10.0	0.888	78.4	0.2639	3.0	1.8	5.0	-	0.6	79.5	84.2
14-1	3	Biosolids	14.217	34.32	4.70	5.32	26.0	1.58	18.0	11.0	30.0	32.6	4.0	1.047	Y	Y	4.2	6.7	3.5	344	13.0	24.9	3.1	21.8	5.7	10.0	0.888	78.4	0.2639	3.0	1.8	5.0	-	0.6	79.5	84.2
14-1	4	Biosolids	14.217	34.32	4.70	5.32	26.0	1.58	18.0	11.0	30.0	32.6	4.0	1.047	Y	Y	4.2	6.7	3.5	344	13.0	24.9	3.1	21.8	5.7	10.0	0.888	78.4	0.2639	3.0	1.8	5.0	-	0.6	79.5	84.2

15-1	1	Manure (Swine)	20.588	47.63	6.29	3.37	30.9	0.55	43.0	21.0	22.0	12.5	4.0	1.047	Y	Y	4.2	6.7	3.5	344	13.0	24.9	3.1	21.8	11.9	9.9	0.839	74.4	0.1370	10.7	5.2	5.5	3.5	2.0	75.4	78.2
15-1	2	Manure (Swine)	20.588	47.63	6.29	3.37	30.9	0.55	43.0	21.0	22.0	12.5	4.0	1.047	Y	Y	4.2	6.7	3.5	344	13.0	24.9	3.1	21.8	11.9	9.9	0.839	74.4	0.1370	10.7	5.2	5.5	3.5	2.0	75.4	78.2
15-1	3	Manure (Swine)	20.588	47.63	6.29	3.37	30.9	0.55	43.0	21.0	22.0	12.5	4.0	1.047	Y	Y	4.2	6.7	3.5	344	13.0	24.9	3.1	21.8	11.9	9.9	0.839	74.4	0.1370	10.7	5.2	5.5	3.5	2.0	75.4	78.2
15-1	4	Manure (Swine)	20.588	47.63	6.29	3.37	30.9	0.55	43.0	21.0	22.0	12.5	4.0	1.051	N	Y	4.2	5.2	3.5	348	1.0	14.6	2.5	12.1	11.9	9.9	0.839	74.4	0.1370	10.7	5.2	5.5	3.5	2.0	75.4	78.2
15-1	5	Manure (Swine)	20.588	47.63	6.29	3.37	30.9	0.55	43.0	21.0	22.0	12.5	4.0	1.051	N	Y	4.2	5.2	3.5	348	1.0	14.6	2.5	12.1	11.9	9.9	0.839	74.4	0.1370	10.7	5.2	5.5	3.5	2.0	75.4	78.2
17-1	1	Sludge	19.550	44.78	6.06	6.07	27.4	0.65	53.9	6.6	25.9	17.1	4.0	1.051	N	Y	4.2	5.2	3.5	348	1.0	14.6	2.5	12.1	6.5	10.4	0.887	79.9	0.0950	7.9	1.0	3.8	3.3	2.1	80.9	83.1
17-1	2	Sludge	19.550	44.78	6.06	6.07	27.4	0.65	53.9	6.6	25.9	17.1	4.0	1.050	N	Y	4.2	5.2	3.5	-	-	17.3	2.3	-	6.5	10.4	0.887	79.9	0.0950	7.9	1.0	3.8	3.3	2.1	80.9	83.1
17-1	3	Sludge	19.550	44.78	6.06	6.07	27.4	0.65	53.9	6.6	25.9	17.1	4.0	1.050	N	Y	4.2	5.2	3.5	-	-	17.3	2.3	-	6.5	10.4	0.887	79.9	0.0950	7.9	1.0	3.8	3.3	2.1	80.9	83.1
17-2	1	Sludge	24.114	51.27	7.24	4.65	19.5	0.56	31.5	12.3	37.8	13.5	3.9	1.043	Y	Y	4.1	6.7	3.4	335	4.2	30.3	3.8	26.5	8.9	10.4	0.804	76.9	0.0969	5.5	2.1	6.5	2.6	0.8	77.8	80.7
17-2	2	Sludge	24.114	51.27	7.24	4.65	19.5	0.56	31.5	12.3	37.8	13.5	3.9	1.043	Y	Y	4.1	6.7	3.4	335	4.2	30.3	3.8	26.5	8.9	10.4	0.804	76.9	0.0969	5.5	2.1	6.5	2.6	0.8	77.8	80.7
18-1	1	FOG & lignin	27.442	59.41	7.70	1.74	20.5	0.39	37.0	38.0	10.0	12.5	3.9	1.043	Y	Y	4.1	6.7	3.4	335	4.2	30.3	3.8	26.5	18.0	10.1	0.527	68.2	0.1182	11.2	11.5	3.0	3.6	3.7	68.8	71.9
18-1	2	FOG & lignin	27.442	59.41	7.70	1.74	20.5	0.39	37.0	38.0	10.0	12.5	4.0	1.010	N	Y	4.0	6.6	3.5	341	1.0	14.6	2.4	12.1	18.0	10.1	0.527	68.2	0.1182	11.2	11.5	3.0	3.6	3.7	68.8	71.9
18-1	3	FOG & lignin	27.442	59.41	7.70	1.74	20.5	0.39	37.0	38.0	10.0	12.5	4.0	1.010	N	Y	4.0	6.6	3.5	341	1.0	14.6	2.4	12.1	18.0	10.1	0.527	68.2	0.1182	11.2	11.5	3.0	3.6	3.7	68.8	71.9
19-1	1	Manure (Bovine)	18.217	43.86	5.74	2.64	34.0	0.49	59.1	9.9	15.4	16.7	4.0	1.010	N	Y	4.0	6.6	3.5	341	1.0	14.6	2.4	12.1	6.4	10.3	0.385	80.9	0.0714	8.6	1.4	2.2	0.9	3.8	81.3	83.3
19-1	2	Manure (Bovine)	18.217	43.86	5.74	2.64	34.0	0.49	59.1	9.9	15.4	16.7	4.0	1.010	N	Y	4.0	6.6	3.5	337	1.3	14.6	2.4	12.1	6.4	10.3	0.385	80.9	0.0714	8.6	1.4	2.2	0.9	3.8	81.3	83.3
19-1	3	Manure (Bovine)	18.217	43.86	5.74	2.64	34.0	0.49	59.1	9.9	15.4	16.7	4.0	1.010	N	Y	4.0	6.6	3.5	337	1.3	14.6	2.4	12.1	6.4	10.3	0.385	80.9	0.0714	8.6	1.4	2.2	0.9	3.8	81.3	83.3
19-2	1	Manure (Bovine)	18.217	43.86	5.74	2.64	34.0	0.49	59.1	9.9	15.4	16.7	4.0	1.010	N	Y	4.0	6.6	3.5	337	1.3	14.6	2.4	12.1	6.4	10.3	0.385	80.9	0.0714	8.6	1.4	2.2	0.9	3.8	81.3	83.3
19-2	2	Manure (Bovine)	18.217	43.86	5.74	2.64	34.0	0.49	59.1	9.9	15.4	16.7	1.8	1.045	Y	N	1.9	4.54	3.6	345	3.3	22.3	1.4	20.8	6.4	10.3	0.385	80.9	0.0714	8.6	1.4	2.2	0.9	3.8	81.3	83.3
19-2	3	Manure (Bovine)	18.217	43.86	5.74	2.64	34.0	0.49	59.1	9.9	15.4	16.7	1.8	1.045	Y	N	1.9	4.54	3.6	345	3.3	22.3	1.4	20.8	6.4	10.3	0.385	80.9	0.0714	8.6	1.4	2.2	0.9	3.8	81.3	83.3
20-1	1	Food waste	21.927	49.32	7.27	3.5	35.5	0.00	53.6	18.6	21.6	6.5	1.8	1.045	Y	N	1.9	4.54	3.6	345	3.3	22.3	1.4	20.8	11.0	10.3	0.781	77.0	0.0000	12.0	4.1	4.8	1.2	2.5	77.8	78.7
20-1	2	Food waste	21.927	49.32	7.27	3.5	35.5	0.00	53.6	18.6	21.6	6.5	3.0	1.045	Y	Y	3.1	4.54	5.9	335	3.3	22.3	1.4	20.8	11.0	10.3	0.781	77.0	0.0000	12.0	4.1	4.8	1.2	2.5	77.8	78.7
20-1	3	Food waste	21.927	49.32	7.27	3.5	35.5	0.00	53.6	18.6	21.6	6.5	3.0	1.045	Y	Y	3.1	4.54	5.9	335	3.3	22.3	1.4	20.8	11.0	10.3	0.781	77.0	0.0000	12.0	4.1	4.8	1.2	2.5	77.8	78.7
20-2	1	Food waste	21.927	49.32	7.27	3.5	35.5	0.00	53.6	18.6	21.6	6.5	3.0	1.045	Y	Y	3.1	4.54	5.9	335	3.3	22.3	1.4	20.8	11.0	10.3	0.781	77.0	0.0000	12.0	4.1	4.8	1.2	2.5	77.8	78.7
20-2	2	Food waste	21.927	49.32	7.27	3.5	35.5	0.00	53.6	18.6	21.6	6.5	3.0	1.084	Y	N	3.3	-	6.0	339	-	25.7	1.1	24.6	11.0	10.3	0.781	77.0	0.0000	12.0	4.1	4.8	1.2	2.5	77.8	78.7
20-2	3	Food waste	21.927	49.32	7.27	3.5	35.5	0.00	53.6	18.6	21.6	6.5	3.0	1.084	Y	N	3.3	-	6.0	339	-	25.7	1.1	24.6	11.0	10.3	0.781	77.0	0.0000	12.0	4.1	4.8	1.2	2.5	77.8	78.7
21-1	1	Food waste	23.265	51.49	7.60	3.31	34.3	0.23	53.1	20.0	20.7	4.1	3.0	1.084	Y	N	3.3	-	6.0	339	-	25.7	1.1	24.6	13.2	10.2	0.850	74.9	0.0591	13.6	5.1	5.3	4.1	2.6	75.8	76.6
21-1	2	Food waste	23.265	51.49	7.60	3.31	34.3	0.23	53.1	20.0	20.7	4.1	3.0	1.084	Y	N	3.3	-	6.0	339	-	25.7	1.1	24.6	13.2	10.2	0.850	74.9	0.0591	13.6	5.1	5.3	4.1	2.6	75.8	76.6
21-1	3	Food waste	23.265	51.49	7.60	3.31	34.3	0.23	53.1	20.0	20.7	4.1	3.0	1.084	Y	N	3.3	-	6.0	339	-	25.7	1.1	24.6	13.2	10.2	0.850	74.9	0.0591	13.6	5.1	5.3	4.1	2.6	75.8	76.6
21-1	4	Food waste	23.265	51.49	7.60	3.31	34.3	0.23	53.1	20.0	20.7	4.1	5.1	1.083	Y	N	5.6	5.44	10.3	337	3.3	19.4	2.6	16.8	13.2	10.2	0.850	74.9	0.0591	13.6	5.1	5.3	4.1	2.6	75.8	76.6
21-1	5	Food waste	23.265	51.49	7.60	3.31	34.3	0.23	53.1	20.0	20.7	4.1	5.1	1.083	Y	N	5.6	5.44	10.3	337	3.3	19.4	2.6	16.8	13.2	10.2	0.850	74.9	0.0591	13.6	5.1	5.3	4.1	2.6	75.8	76.6
22-1	1	Blend	22.080	48.15	7.28	4.73	29.1	0.58	31.3	23.3	30.2	13.5	5.1	1.083	Y	N	5.6	5.44	10.3	337	3.3	19.4	2.6	16.8	9.3	10.4	0.918	77.3	0.1125	6.1	4.5	5.8	3.2	1.0	78.3	80.3
22-1	2	Blend	22.080	48.15	7.28	4.73	29.1	0.58	31.3	23.3	30.2	13.5	5.1	1.083	Y	N	5.6	5.44	10.3	337	3.3	19.4	2.6	16.8	9.3	10.4	0.918	77.3	0.1125	6.1	4.5	5.8	3.2	1.0	78.3	80.3
22-1	3	Blend	22.080	48.15	7.28	4.73	29.1	0.58	31.3	23.3	30.2	13.5	5.0	1.077	Y	N	5.4	5.43	10.0	337	3.3	24.3	3.2	21.3	9.3	10.4	0.918	77.3	0.1125	6.1	4.5	5.8	3.2	1.0	78.3	80.3
22-1	4	Blend	22.080	48.15	7.28	4.73	29.1	0.58	31.3	23.3	30.2	13.5	5.0	1.077	Y	N	5.4	5.43	10.0	337	3.3	24.3	3.2	21.3	9.3	10.4	0.918	77.3	0.1125	6.1	4.5	5.8	3.2	1.0	78.3	80.3
22-2	1	Blend	21.872	47.86	7.38	4.52	31.4	0.57	31.3	23.3	30.2	13.2	5.0	1.077	Y	N	5.4	5.43	10.0	337	3.3	24.3	3.2	21.3	11.6	10.2	1.096	74.9	0.1382	7.6	5.6	7.3	4.0	1.0	76.2	78.2
22-2	2	Blend	21.872	47.86	7.38	4.52	31.4	0.57	31.3	23.3	30.2	13.2	5.0	1.077	Y	N	5.4	5.43	10.0	337	3.3	24.3	3.2	21.3	11.6	10.2	1.096	74.9	0.1382	7.6	5.6	7.3	4.0	1.0	76.2	78.2
22-2	3	Blend	21.872	47.86	7.38	4.52	31.4	0.57	31.3	23.3	30.2	13.2	5.0	1.077	Y	N	5.4	5.43	10.0	337	3.3	24.3	3.2	21.3	11.6	10.2	1.096	74.9	0.1382	7.6	5.6	7.3	4.0	1.0	76.2	78.2
22-2	4	Blend	21.872	47.86	7.38	4.52	31.4	0.57	31.3	23.3	30.2	13.2	3.0	1.011	Y	N	3.0	5.9	5.5	337	1.0	18.7	1.6	17.1	11.6	10.2	1.096	74.9	0.1382	7.6	5.6	7.3	4.0	1.0	76.2	78.2
22-2	5	Blend	21.872	47.86	7.38	4.52	31.4	0.57	31.3	23.3	30.2	13.2	3.0	1.011	Y	N	3.0	5.9	5.5	337	1.0	18.7	1.6	17.1	11.6	10.2	1.096	74.9	0.1382	7.6	5.6	7.3	4.0	1.0	76.2	78.2
23-1	1	Food waste	22.012	50.77	6.64	3.17	32.2	0.25	41.4	27.7	22.8	8.6	3.0	1.011	Y	N	3.0	5.9	5.5	337	1.0	18.7	1.6	17.1	9.5	10.3	0.593	78.3	0.0468	7.7	5.2	4.3	4.0	1.8	78.9	80.2
23-1	2	Food waste	22.012	50.77	6.64	3.17	32.2	0.25	41.4	27.7	22.8	8.6	3.0	1.040	Y	N	3.1	4.25	5.5	337	1.3	18.3	2.0	16.2	9.5	10.3	0.593	78.3	0.0468	7.7	5.2	4.3	4.0	1.8	78.9	80.2
23-1	3	Food waste	22.012	50.77	6.64	3.17	32.2	0.25	41.4	27.7	22.8	8.6	3.0	1.040	Y	N	3.1	4.25	5.5	337	1.3	18.3	2.0	16.2	9.5	10.3	0.593	78.3	0.0468	7.7	5.2	4.3	4.0	1.8	78.9	80.2
23-2	1	Food waste	20.027	46.86	6.12	3.2	31.8	0.24	41.4	27.7	22.8	11.1	3.0	1.040	Y	N	3.1	4.25	5.5	337	1.3	18.3	2.0	16.2	8.6	10.2	0.585	78.5	0.0438	7.6	5.1	4.2	3.9	1.8	79.1	81.2
23-2	2	Food waste	20.027	46.86	6.12	3.2	31.8	0.24	41.4	27.7	22.8	11.1	3.0	1.040	Y	N	3.1	4.25	5.5	337	1.3	18.3	2.0	16.2	8.6	10.2	0.585	78.5	0.0438	7.6	5.1	4.2	3.9	1.8	79.1	81.2
23-2	3	Food waste	20.027	46.86	6.12	3.2	31.8	0.24	41.4	27.7	22.8	11.1	1.5	1.050	Y	Y	1.6	7.1	2.1	339	3.3	16.8	1.9	14.9	8.6	10.2	0.585	78.5	0.0438	7.6	5.1	4.2	3.9	1.8	79.1	81.2
23-2	4	Food waste	20.027	46.86	6.12	3.2	31.8	0.24	41.4	27.7	22.8	11.1	1.5	1.050	Y	Y	1.6	7.1	2.1	339	3.3	16.8	1.9	14.9	8.6	10.2	0.585	78.5	0.0438	7.6	5.1	4.2	3.9	1.8	79.1	81.2

Table S5 – Listing of mass balance and biocrude property variables for each of the wet waste HTL runs conducted in this study

		Mass balance variables																			Biocrude variables													
Run	**Set aside**	**Biocrude mass yield (wt%)**	**Solids mass yield (wt%)**	**Gas mass yield (wt%)**	**Aqueous mass yield (wt%)**	**Total mass yield (wt%)**	**Biocrude production rate (g/h)**	**Biocrude mass yield (daf wt%)**	**Solids mass yield (daf wt%)**	**Gas mas yield (daf wt%)**	**Aqueous mass yield (wt%)**	**Biocrude yield (C%)**	**Solids yield (C%)**	**Gas yield (C%)**	**Aqueous yield (C%)**	**Total yield (C%)**	**Biocrude yield (normalized) (C%)**	**Solids yield (normalized) (C%)**	**Gas yield (normalized) (C%)**	**Aqueous yield (normalized) (C%)**	**Biocrude C content (wt%)**	**Biocrude H content (wt%)**	**Biocrude H:C (wt%)**	**Biocrude O content (wt%)**	**Biocrude N content (wt%)**	**Biocrude S content (wt%)**	**Biocrude HHV (MJ/kg)**	**Biocrude TAN (mgKOH/g oil)**	**Biocrude density (at 40 °C) (g/mL)**	**Biocrude viscosity (at 40 °C) (cSt)**	**Biocrude moisture content (wt%)**	**Biocrude ash content (dry) (wt%)**	**Biocrude filterable solids content (dry) (wt%)**
2-1	1	6.3	2.1	2.7	92.7	103.8	98.8	42.1	6.3	18.4	33.1	58.6	8.5	9.2	30.8	107.1	54.7	7.9	8.6	28.8	76.1	9.6	1.50	5.8	1.8	0.1	37.239	70.3	1.050	4115.0	6.2	0.430	1.500
2-1	2	6.2	2.1	2.7	87.8	98.8	97.7	41.7	6.3	18.4	33.6	57.9	8.5	9.2	29.2	104.8	55.3	8.1	8.8	27.9	76.1	9.6	1.50	5.8	1.8	0.1	37.239	70.3	1.050	4115.0	6.2	0.430	1.500
2-1	3	6.4	2.1	2.7	89.8	101.1	101.4	43.3	6.3	18.4	32.0	60.1	8.5	9.2	29.9	107.7	55.8	7.9	8.5	27.7	76.1	9.6	1.50	5.8	1.8	0.1	37.239	70.3	1.050	4115.0	6.2	0.430	1.500
2-1	4	5.7	2.1	2.7	90.6	101.1	89.4	38.1	6.3	18.4	37.2	53.0	8.5	9.2	30.1	100.8	52.6	8.4	9.1	29.9	76.1	9.6	1.50	5.8	1.8	0.1	37.239	70.3	1.050	4115.0	6.2	0.430	1.500
2-1	5	6.5	2.1	2.7	90.0	101.4	102.7	43.8	6.3	18.4	31.4	60.9	8.5	9.2	29.9	108.6	56.1	7.8	8.5	27.6	76.1	9.6	1.50	5.8	1.8	0.1	37.239	70.3	1.050	4115.0	6.2	0.430	1.500
5-1	1	5.0	0.4	3.2	92.8	101.5	208.8	39.3	1.6	27.7	31.4	60.4	2.4	15.1	27.9	105.7	57.2	2.2	14.2	26.4	77.3	10.7	1.65	7.2	4.2	0.3	38.840	68.0	1.040	8127.0	14.0	0.150	0.230
5-1	2	4.7	0.4	3.2	93.1	101.5	194.7	36.7	1.6	27.7	34.0	56.4	2.4	15.1	28.0	101.7	55.4	2.3	14.8	27.5	77.3	10.7	1.65	7.2	4.2	0.3	38.840	68.0	1.040	8127.0	14.0	0.150	0.230
6-1	1	6.6	6.3	3.1	84.1	100.2	141.8	44.1	13.4	22.7	19.8	60.2	16.9	10.0	24.0	111.1	54.2	15.2	9.0	21.6	75.9	10.6	1.66	5.3	10.6	1.0	38.427	52.2	0.980	350.0	3.3	0.120	0.150
6-1	2	6.7	6.3	3.1	87.6	103.7	144.5	44.9	13.4	22.7	19.0	61.3	16.9	10.0	25.0	113.2	54.2	14.9	8.8	22.1	75.9	10.6	1.66	5.3	10.6	1.0	38.427	52.2	0.980	350.0	3.3	0.120	0.150
6-1	3	7.0	6.3	3.1	82.4	98.9	151.1	46.9	13.4	22.7	17.0	64.1	16.9	10.0	23.5	114.5	56.0	14.8	8.7	20.5	75.9	10.6	1.66	5.3	10.6	1.0	38.427	52.2	0.980	350.0	3.3	0.120	0.150
6-2	1	6.7	5.5	3.1	85.4	100.7	287.8	44.9	8.7	22.4	24.0	62.1	11.1	9.5	25.3	107.9	57.5	10.3	8.8	23.4	76.8	10.0	1.55	4.8	4.9	1.2	38.122	78.0	0.980	355.0	4.4	0.060	0.120
6-2	2	6.6	5.5	3.1	85.3	100.5	282.8	44.2	8.7	22.4	24.7	61.0	11.1	9.5	25.3	106.8	57.1	10.4	8.9	23.6	76.8	10.0	1.55	4.8	4.9	1.2	38.122	78.0	0.980	355.0	4.4	0.060	0.120
6-3	3	6.7	5.5	3.1	86.1	101.3	284.6	44.4	8.7	22.4	24.5	61.4	11.1	9.5	25.5	107.4	57.1	10.3	8.8	23.7	76.8	10.0	1.55	4.8	4.9	1.2	38.122	78.0	0.980	355.0	4.4	0.060	0.120
9-1	1	5.6	3.6	3.7	92.3	105.1	235.3	38.4	5.4	27.8	28.4	56.9	6.9	13.6	33.2	110.6	51.5	6.2	12.3	30.0	77.1	10.0	1.54	6.9	5.2	0.4	37.897	56.0	0.990	392.0	4.0	0.070	0.190
9-1	2	5.6	3.6	3.7	86.8	99.7	238.1	38.9	5.4	27.8	28.0	57.6	6.9	13.6	31.2	109.3	52.7	6.3	12.4	28.6	77.1	10.0	1.54	6.9	5.2	0.4	37.897	56.0	0.990	392.0	4.0	0.070	0.190
9-1	3	5.6	3.6	3.7	85.5	98.4	236.3	38.6	5.4	27.8	28.3	57.1	6.9	13.6	30.8	108.4	52.7	6.3	12.5	28.4	77.1	10.0	1.54	6.9	5.2	0.4	37.897	56.0	0.990	392.0	4.0	0.070	0.190
9-1	4	4.9	3.6	3.7	87.9	100.2	209.1	34.1	5.4	27.8	32.7	50.6	6.9	13.6	31.6	102.7	49.3	6.7	13.2	30.8	77.1	10.0	1.54	6.9	5.2	0.4	37.897	56.0	0.990	392.0	4.0	0.070	0.190
9-1	5	5.4	3.6	3.7	87.3	100.0	226.6	37.0	5.4	27.8	29.8	54.8	6.9	13.6	31.4	106.7	51.4	6.4	12.7	29.5	77.1	10.0	1.54	6.9	5.2	0.4	37.897	56.0	0.990	392.0	4.0	0.070	0.190
10-1	1	7.9	2.5	2.6	88.0	101.0	338.9	56.7	4.9	20.8	17.6	73.7	6.0	9.4	29.1	118.3	62.3	5.1	8.0	24.6	77.8	10.9	1.67	9.3	3.5	0.3	39.203	106.0	0.950	166.0	2.6	0.050	0.130
10-1	2	7.4	2.5	2.6	85.0	97.6	317.6	53.1	4.9	20.8	21.2	69.1	6.0	9.4	28.2	112.7	61.3	5.4	8.4	25.0	77.8	10.9	1.67	9.3	3.5	0.3	39.203	106.0	0.950	166.0	2.6	0.050	0.130
10-1	3	7.0	2.5	2.6	87.5	99.6	301.0	50.3	4.9	20.8	23.9	65.5	6.0	9.4	29.0	109.9	59.6	5.5	8.6	26.4	77.8	10.9	1.67	9.3	3.5	0.3	39.203	106.0	0.950	166.0	2.6	0.050	0.130
10-1	4	6.7	2.5	2.6	84.7	96.5	286.4	47.9	4.9	20.8	26.4	62.3	6.0	9.4	28.1	105.8	58.9	5.7	8.9	26.5	77.8	10.9	1.67	9.3	3.5	0.3	39.203	106.0	0.950	166.0	2.6	0.050	0.130
10-1	5	6.8	2.5	2.6	91.6	103.5	293.1	49.0	4.9	20.8	25.3	63.7	6.0	9.4	30.3	109.5	58.2	5.5	8.6	27.7	77.8	10.9	1.67	9.3	3.5	0.3	39.203	106.0	0.950	166.0	2.6	0.050	0.130
10-1	6	7.0	2.5	2.6	83.8	96.0	302.8	50.6	4.9	20.8	23.6	65.8	6.0	9.4	27.8	109.1	60.4	5.5	8.7	25.5	77.8	10.9	1.67	9.3	3.5	0.3	39.203	106.0	0.950	166.0	2.6	0.050	0.130
14-1	1	3.7	7.3	2.0	77.8	90.9	159.0	32.6	17.3	19.7	30.4	49.1	21.3	9.0	30.2	109.6	44.8	19.4	8.2	27.6	76.7	9.4	1.46	6.3	5.1	1.8	37.310	31.3	1.010	-	7.3	1.040	1.390
14-1	2	3.3	7.3	2.0	86.8	99.4	141.8	29.1	17.3	19.7	33.9	43.8	21.3	9.0	33.7	107.8	40.6	19.8	8.3	31.3	76.7	9.4	1.46	6.3	5.1	1.8	37.310	31.3	1.010	-	7.3	1.040	1.390
14-1	3	3.1	7.3	2.0	85.6	98.1	135.2	27.7	17.3	19.7	35.3	41.8	21.3	9.0	33.3	105.3	39.7	20.2	8.5	31.6	76.7	9.4	1.46	6.3	5.1	1.8	37.310	31.3	1.010	-	7.3	1.040	1.390
14-1	4	3.3	7.3	2.0	87.7	100.3	144.0	29.5	17.3	19.7	33.5	44.5	21.3	9.0	34.0	108.8	40.9	19.6	8.2	31.3	76.7	9.4	1.46	6.3	5.1	1.8	37.310	31.3	1.010	-	7.3	1.040	1.390
15-1	1	11.9	3.0	5.7	83.7	104.3	499.7	54.7	5.5	28.8	11.0	70.9	7.4	14.6	24.2	117.1	60.5	6.4	12.5	20.6	70.5	10.0	1.69	13.5	4.4	0.6	34.965	57.5	0.960	1038.0	5.0	0.280	0.260
15-1	2	9.6	3.0	5.7	86.4	104.7	404.1	44.2	5.5	28.8	21.5	57.3	7.4	14.6	24.9	104.3	54.9	7.1	14.0	23.9	70.5	10.0	1.69	13.5	4.4	0.6	34.965	57.5	0.960	1038.0	5.0	0.280	0.260
15-1	3	10.6	3.0	5.7	85.8	105.1	445.0	48.7	5.5	28.8	17.0	63.1	7.4	14.6	24.8	110.0	57.4	6.8	13.3	22.5	70.5	10.0	1.69	13.5	4.4	0.6	34.965	57.5	0.960	1038.0	5.0	0.280	0.260
15-1	4	12.3	3.0	5.7	86.8	107.7	514.5	56.3	5.5	28.8	9.4	73.0	7.4	14.6	25.0	120.1	60.8	6.2	12.2	20.8	70.5	10.0	1.69	13.5	4.4	0.6	34.965	57.5	0.960	1038.0	5.0	0.280	0.260
15-1	5	10.3	3.0	5.7	86.0	104.9	429.9	47.1	5.5	28.8	18.6	61.0	7.4	14.6	24.8	107.9	56.5	6.9	13.6	23.0	70.5	10.0	1.69	13.5	4.4	0.6	34.965	57.5	0.960	1038.0	5.0	0.280	0.260
17-1	1	5.2	1.9	3.1	89.0	99.2	220.8	40.7	3.9	26.3	29.1	61.0	5.6	13.9	31.5	111.9	54.5	5.0	12.4	28.2	76.3	9.8	1.53	8.6	5.0	0.6	37.293	51.2	0.960	-	7.0	0.160	0.550
17-1	2	4.8	1.9	3.1	89.2	99.0	201.9	37.1	3.9	26.2	32.8	55.5	5.6	13.8	31.5	106.3	52.2	5.2	13.0	29.6	76.3	9.8	1.53	8.6	5.0	0.6	37.293	51.2	0.960	-	7.0	0.160	0.550
17-1	3	4.9	1.9	3.1	90.5	100.3	205.7	37.9	3.9	26.3	31.9	56.8	5.6	13.9	32.0	108.2	52.5	5.2	12.8	29.6	76.3	9.8	1.53	8.6	5.0	0.6	37.293	51.2	0.960	-	7.0	0.160	0.550
17-2	1	4.6	1.9	3.1	89.5	99.1	195.2	30.9	3.4	22.5	43.2	39.7	4.1	10.2	27.2	81.2	48.9	5.1	12.6	33.5	76.3	9.6	1.50	8.8	5.4	0.7	36.966	51.9	0.960	-	6.6	0.160	0.550
17-2	2	5.7	1.9	3.1	89.5	100.2	242.9	38.4	3.4	22.5	35.7	49.4	4.1	10.2	27.2	90.9	54.3	4.5	11.2	29.9	76.3	9.6	1.50	8.8	5.4	0.7	36.966	51.9	0.960	-	6.6	0.160	0.550
18-1	1	18.3	6.2	1.7	79.1	105.3	751.2	67.1	14.1	6.8	12.0	75.5	16.0	2.7	8.5	102.7	73.5	15.6	2.6	8.3	75.7	11.2	1.76	14.5	1.7	0.1	38.100	205.0	0.960	27000.0	5.1	0.560	3.620
18-1	2	18.8	6.2	1.7	76.0	102.6	772.4	71.3	14.6	7.0	7.1	79.8	16.5	2.8	8.4	107.4	74.3	15.4	2.6	7.8	75.7	11.2	1.76	14.5	1.7	0.1	38.100	205.0	0.960	27000.0	5.1	0.560	3.620
18-1	3	17.4	6.2	1.7	67.7	93.0	714.0	65.5	14.5	6.9	13.1	73.2	16.4	2.7	7.4	99.8	73.4	16.4	2.7	7.4	75.7	11.2	1.76	14.5	1.7	0.1	38.100	205.0	0.960	27000.0	5.1	0.560	3.620
19-1	1	3.8	2.0	2.9	98.0	106.7	152.7	30.8	6.3	26.2	36.7	45.3	10.1	13.6	29.0	98.0	46.2	10.4	13.9	29.6	76.7	9.7	1.51	13.8	3.9	0.4	36.760	36.1	1.035	780.2	4.5	0.386	0.662
19-1	2	4.7	2.0	2.9	99.2	108.7	188.6	38.1	6.3	26.2	29.5	55.9	10.1	13.6	29.3	109.0	51.3	9.3	12.5	26.9	76.7	9.7	1.51	13.8	3.9	0.4	36.760	36.1	1.035	780.2	4.5	0.386	0.662
19-1	3	4.4	2.0	2.9	96.1	105.4	177.4	35.8	6.3	26.2	31.7	52.6	10.1	13.6	28.4	104.8	50.2	9.7	13.0	27.1	76.7	9.7	1.51	13.8	3.9	0.4	36.760	36.1	1.035	780.2	4.5	0.386	0.662
19-2	1	5.2	1.8	3.6	90.0	100.5	209.0	42.4	4.2	32.1	21.2	63.1	8.1	17.0	26.8	115.0	54.9	7.0	14.8	23.3	76.9	9.6	1.49	14.3	4.1	0.3	36.660	24.3	1.044	1349.3	4.8	0.217	1.673
19-2	2	5.7	1.8	3.6	92.5	103.5	227.9	46.3	4.2	32.1	17.4	68.8	8.1	17.0	27.6	121.5	56.6	6.6	14.0	22.7	76.9	9.6	1.49	14.3	4.1	0.3	36.660	24.3	1.044	1349.3	4.8	0.217	1.673
19-2	3	4.7	1.8	3.6	88.0	98.0	188.2	38.2	4.2	32.1	25.5	56.8	8.1	17.0	26.3	108.1	52.5	7.5	15.7	24.3	76.9	9.6	1.49	14.3	4.1	0.3	36.660	24.3	1.044	1349.3	4.8	0.217	1.673
20-1	1	8.9	0.4	2.5	82.3	94.1	168.1	42.8	7.1	13.1	36.9	62.7	11.4	6.8	22.3	103.3	60.7	11.0	6.6	21.6	77.3	11.2	1.73	8.4	4.3	0.4	39.288	107.9	0.998	786.2	2.6	0.100	0.080
20-1	2	7.9	0.4	2.5	81.9	92.8	149.1	38.0	7.1	13.1	41.8	55.6	11.4	6.8	22.2	96.1	57.9	11.9	7.1	23.1	77.3	11.2	1.73	8.4	4.3	0.4	39.288	107.9	0.998	786.2	2.6	0.100	0.080
20-1	3	8.3	0.4	2.5	87.5	98.8	156.4	39.8	7.1	13.1	39.9	58.4	11.4	6.8	23.0	99.6	58.6	11.5	6.8	23.1	77.3	11.2	1.73	8.4	4.3	0.4	39.288	107.9	0.998	786.2	2.6	0.100	0.080
20-2	1	9.8	0.3	2.5	87.2	99.7	303.6	47.0	3.2	13.2	36.6	68.4	6.0	6.7	22.1	103.1	66.3	5.8	6.5	21.4	76.8	4.2	1.71	8.7	4.2	0.4	38.891	112.2	1.001	987.9	2.3	0.100	0.088
20-2	2	7.4	0.3	2.5	82.4	92.6	228.9	35.4	3.2	13.2	48.2	51.5	6.0	6.7	20.9	85.1	60.6	7.0	7.9	24.5	76.8	4.2	1.71	8.7	4.2	0.4	38.891	112.2	1.001	987.9	2.3	0.100	0.088
20-2	3	10.0	0.3	2.5	93.8	106.6	311.0	48.1	3.2	13.2	35.5	70.0	6.0	6.7	26.0	108.7	64.4	5.5	6.2	23.9	76.8	4.2	1.71	8.7	4.2	0.4	38.891	112.2	1.001	987.9	2.3	0.100	0.088
21-1	1	10.3	0.8	4.4	81.8	97.3	336.0	42.0	1.8	19.9	36.4	59.8	2.6	10.1	22.3	94.8	63.1	2.7	10.7	23.5	76.6	11.1	1.72	10.6	3.9	0.2	38.650	7.5	1.007	617.1	4.8	0.112	0.063
21-1	2	10.1	0.8	4.4	79.4	94.7	328.5	41.0	1.8	19.9	37.3	58.5	2.6	10.1	21.6	92.8	63.0	2.8	10.9	23.3	76.6	11.1	1.72	10.6	3.9	0.2	38.650	7.5	1.007	617.1	4.8	0.112	0.063
21-1	3	10.6	0.8	4.4	78.6	94.4	345.3	43.1	1.8	19.9	35.2	61.5	2.6	10.1	18.7	92.9	66.2	2.8	10.9	20.2	76.6	11.1	1.72	10.6	3.9	0.2	38.650	7.5	1.007	617.1	4.8	0.112	0.063

21-1	4	10.4	0.8	4.4	80.7	96.3	337.2	42.1	1.8	19.9	36.2	60.0	2.6	10.1	19.3	92.0	65.3	2.8	11.0	20.9	76.6	11.1	1.72	10.6	3.9	0.2	38.650	7.5	1.007	617.1	4.8	0.112	0.063
21-1	5	10.3	0.8	4.4	84.3	99.7	333.8	41.7	1.8	19.9	36.7	59.4	2.6	10.1	20.1	92.2	64.4	2.8	11.0	21.8	76.6	11.1	1.72	10.6	3.9	0.2	38.650	7.5	1.007	617.1	4.8	0.112	0.063
22-1	1	6.0	3.0	2.9	73.9	85.8	335.3	36.0	7.0	19.0	38.1	49.8	8.6	9.4	21.8	89.6	55.6	9.6	10.5	24.3	77.0	11.3	1.75	8.1	4.8	0.7	39.398	99.7	0.964	42.0	3.7	0.170	0.138
22-1	2	6.2	3.0	2.9	74.3	86.4	342.5	36.7	7.0	19.0	37.3	50.9	8.6	9.4	21.9	90.8	56.0	9.4	10.4	24.2	77.0	11.3	1.75	8.1	4.8	0.7	39.398	99.7	0.964	42.0	3.7	0.170	0.138
22-1	3	6.9	3.0	2.9	83.0	95.8	383.1	41.1	7.0	19.0	33.0	56.9	8.6	9.4	24.5	99.4	57.3	8.6	9.5	24.6	77.0	11.3	1.75	8.1	4.8	0.7	39.398	99.7	0.964	42.0	3.7	0.170	0.138
22-1	4	7.4	3.0	2.9	76.2	89.6	413.8	44.4	7.0	19.0	29.7	61.4	8.6	9.4	22.5	101.9	60.3	8.4	9.2	22.1	77.0	11.3	1.75	8.1	4.8	0.7	39.398	99.7	0.964	42.0	3.7	0.170	0.138
22-2	1	7.9	3.0	3.6	74.9	89.3	426.5	37.5	5.5	18.9	38.2	52.0	6.8	9.4	22.1	90.3	57.6	7.5	10.4	24.5	76.5	11.6	1.81	8.0	4.9	0.7	39.584	95.9	0.964	45.0	4.6	0.138	0.138
22-2	2	10.1	3.0	3.6	81.1	97.7	544.5	47.9	5.5	18.9	27.8	66.4	6.8	9.4	23.9	106.6	62.3	6.4	8.9	22.5	76.5	11.6	1.81	8.0	4.9	0.7	39.584	95.9	0.964	45.0	4.6	0.138	0.138
22-2	3	8.7	3.0	3.6	79.2	94.4	468.8	41.2	5.5	18.9	34.5	57.2	6.8	9.4	23.4	96.8	59.1	7.0	9.7	24.1	76.5	11.6	1.81	8.0	4.9	0.7	39.584	95.9	0.964	45.0	4.6	0.138	0.138
22-2	4	9.4	3.0	3.6	79.8	95.8	507.9	44.6	5.5	18.9	31.0	61.9	6.8	9.4	23.5	101.7	60.9	6.7	9.3	23.2	76.5	11.6	1.81	8.0	4.9	0.7	39.584	95.9	0.964	45.0	4.6	0.138	0.138
22-2	5	9.2	3.0	3.6	79.8	95.6	499.5	43.9	5.5	18.9	31.8	60.9	6.8	9.4	23.6	100.7	60.5	6.7	9.4	23.4	76.5	11.6	1.81	8.0	4.9	0.7	39.584	95.9	0.964	45.0	4.6	0.138	0.138
23-1	1	7.9	0.6	2.8	94.8	106.2	238.6	46.1	2.1	18.2	33.7	63.8	2.6	8.9	27.6	102.9	62.0	2.5	8.6	26.8	77.0	9.6	1.48	9.4	4.3	0.7	37.184	120.7	0.976	508.4	1.7	0.030	0.085
23-1	2	7.8	0.6	2.8	94.8	106.0	235.8	45.5	2.1	18.2	34.2	63.1	2.6	8.9	27.6	102.2	61.8	2.5	8.7	27.0	77.0	9.6	1.48	9.4	4.3	0.7	37.184	120.7	0.976	508.4	1.7	0.030	0.085
23-1	3	7.7	0.6	2.8	92.9	104.1	234.9	45.3	2.1	18.2	34.4	62.9	2.6	8.9	27.0	101.4	62.0	2.5	8.8	26.7	77.0	9.6	1.48	9.4	4.3	0.7	37.184	120.7	0.976	508.4	1.7	0.030	0.085
23-2	1	7.5	0.8	3.2	85.8	97.2	234.0	46.1	2.8	21.7	29.4	67.1	4.0	10.3	23.1	104.5	64.2	3.8	9.8	22.1	76.7	9.8	1.51	8.8	4.1	0.7	37.354	119.1	0.971	311.5	2.5	0.029	0.068
23-2	2	6.9	0.8	3.2	87.1	98.0	214.7	42.3	2.8	21.7	33.2	61.5	4.0	10.3	23.5	99.3	62.0	4.0	10.3	23.6	76.7	9.8	1.51	8.8	4.1	0.7	37.354	119.1	0.971	311.5	2.5	0.029	0.068
23-2	3	7.5	0.8	3.2	88.1	99.6	235.3	46.3	2.8	21.7	29.1	67.5	4.0	10.3	23.7	105.5	64.0	3.8	9.7	22.5	76.7	9.8	1.51	8.8	4.1	0.7	37.354	119.1	0.971	311.5	2.5	0.029	0.068
23-2	4	7.4	0.8	3.2	90.2	101.7	232.5	45.8	2.8	21.7	29.7	66.7	4.0	10.3	24.3	105.2	63.3	3.8	9.8	23.1	76.7	9.8	1.51	8.8	4.1	0.7	37.354	119.1	0.971	311.5	2.5	0.029	0.068

Impact of HTL reactor configuration on biocrude yield and properties

The focal point of this study is the comparison of a range of different feedstock types under the same set of HTL operating conditions and analytical techniques. However, two slightly different reactor configurations were utilized, specifically relating to the presence or absence of a CSTR (see Figure 1 of the manuscript). The choice to use the CSTR or not was made based on both the evolving nature of the reactor design (as a consequence of experience gained throughout the experimental work conducted), and the ash content of the feed. The CSTR was effective at limiting the impact of reactor blockage as a result of excessive solids accumulation. As a result, each feed composition was only tested using a single reactor configuration, and most feed types were also only tested exclusively with or without the CSTR. Two feed types, food waste, and blends were utilized in runs using both reactor configurations. With regards to the impact of reactor configuration on biocrude yield, the variation in results was minimal but consistent. In both instances, the average biocrude yield observed for each feed type increased slightly when the CSTR was used. For food waste, the increase was from 62.6 to 63.8 C%, and for blends 58.8 to 60.1 C%. In terms of biocrude quality, no significant variations were observed for key characteristics such as heteroatom content, HHV, density, and TAN. This information is presented in Figure S2.

Given the limited and specific manner in which the reactor configuration was varied across this study, this change should have a limited or negligible impact on the conclusions drawn. There is however some evidence to suggest that the inclusion of the CSTR has a slight positive impact on biocrude yield, without negatively impacting biocrude quality. This observation, in combination with the improved management of residual solids associated with the use of the CSTR, suggests that its use should remain as standard in future work for tests aimed at maximizing biocrude recovery and ease of operations at the bench scale. For testing focused on HTL operations in a pure plug flow reactor configuration, removal of the CSTR does not detract greatly from the maximum biocrude yield.

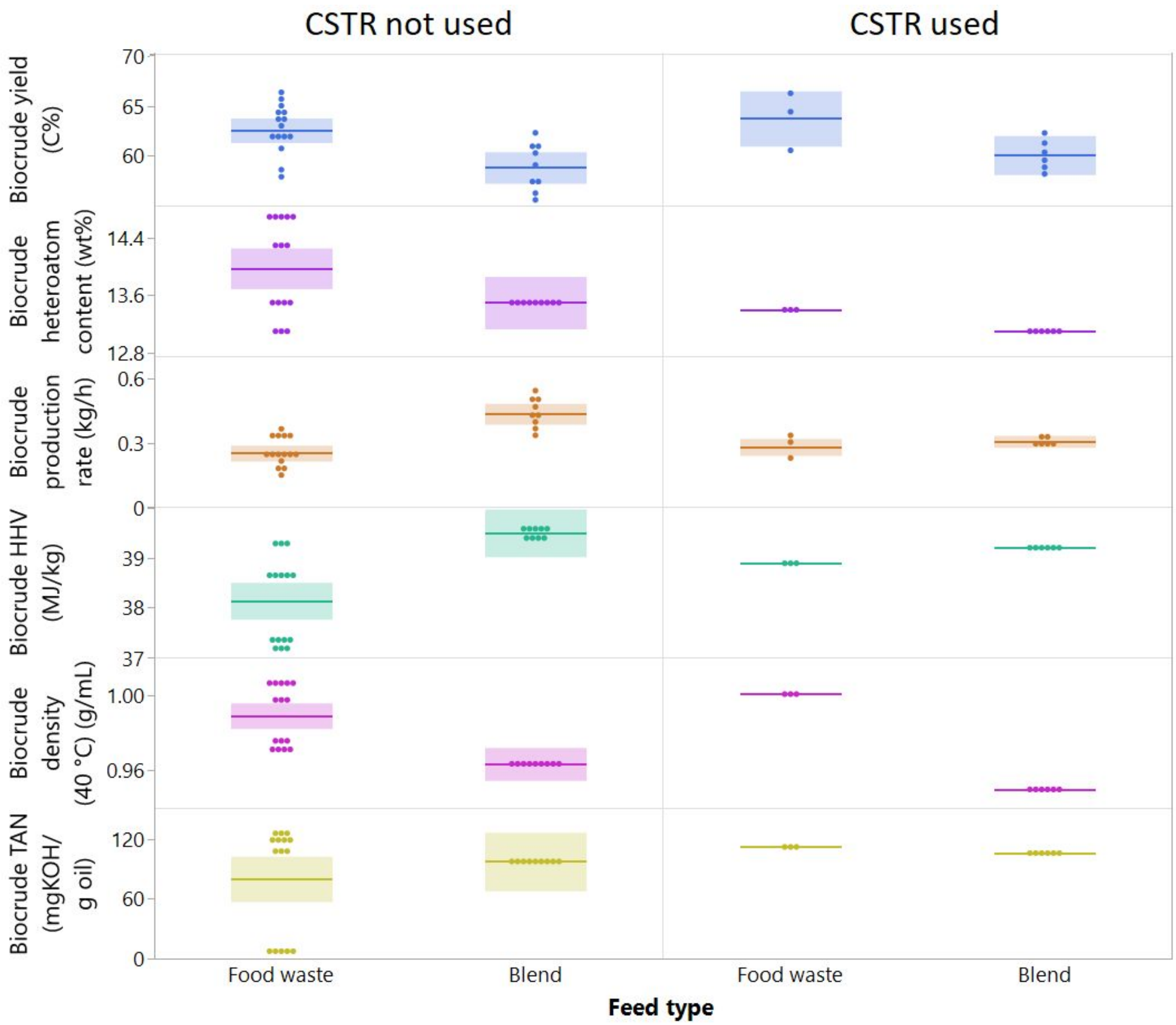

Figure S2 - Biocrude yield and quality data grouped by feedstock type and reactor configuration (inclusion and exclusion of a continuous stirred tank reactor) for wet-waste continuous flow HTL runs

References

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