Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

A synergistic use of microalgae and macroalgae for heavy metal bioremediation and bioenergy production through hydrothermal liquefaction

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SUPPORTING INFORMATION

Table S1 All metal and P analysis was conducted using ICP-MS, all samples lying out of the calibration range, listed here, were reanalysed using ICP-OES

Algae	**Metal loading (mM)**	**Related figure in text**	**Analysis**
Chlorella	10	Figure 1, 2, 3	Aqueous ICP-OES
Spirulina	10	Figure 1, 2, 3	Aqueous ICP-OES
Ulva	50	Figure 1, 2, 3	Aqueous ICP-OES
Sargassam	150	Figure 1, 2, 3	Aqueous ICP-OES
Ulva	150	Figure 1, 2, 3	Aqueous ICP-OES
Chlorella	10 (Zn)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Chlorella	10 (Cu)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Chlorella	10 (Ni)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Chlorella	10 (Cd)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Spirulina	10 (Cu)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Spirulina	10 (Ni)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Spirulina	10 (Cd)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Ulva	10 (Cd)	Figure 4, 5, 6, 7	Aqueous ICP-OES
Sargassam	10	Figure 1, 2, 3	Solid ICP-OES
Ulva	10	Figure 1, 2, 3	Solid ICP-OES

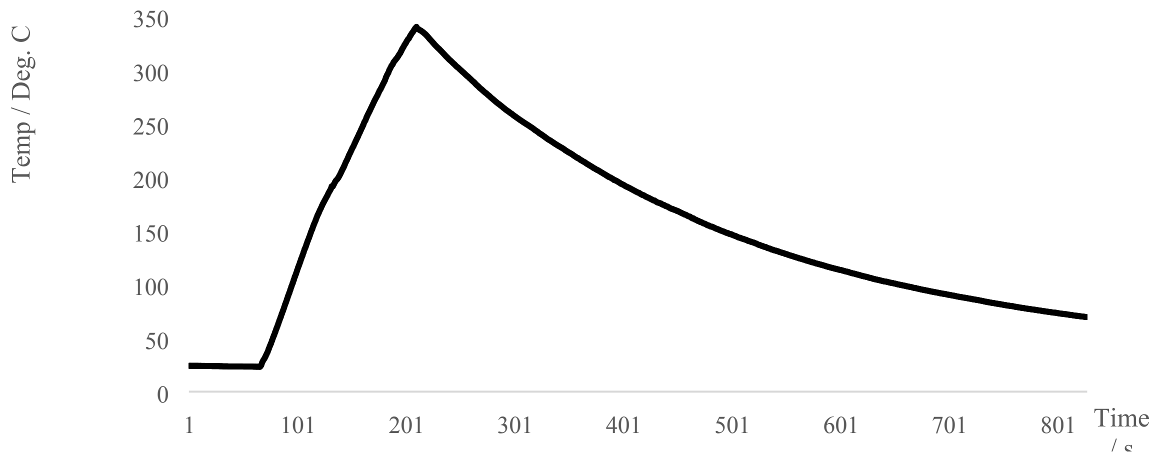

Figure S1. Typical temperature profile for the HTL reaction

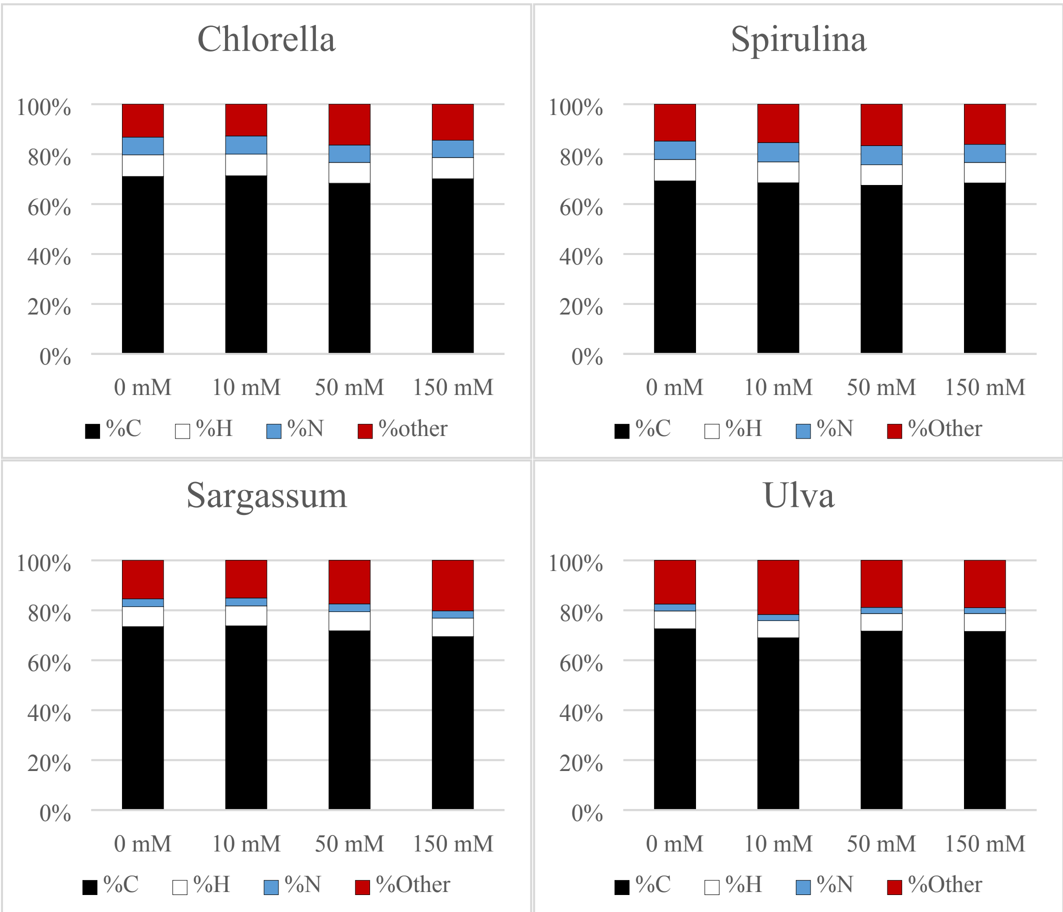

Figure S2. Elemental analysis of the bio-crudes produced from the HTL of the algal biomass

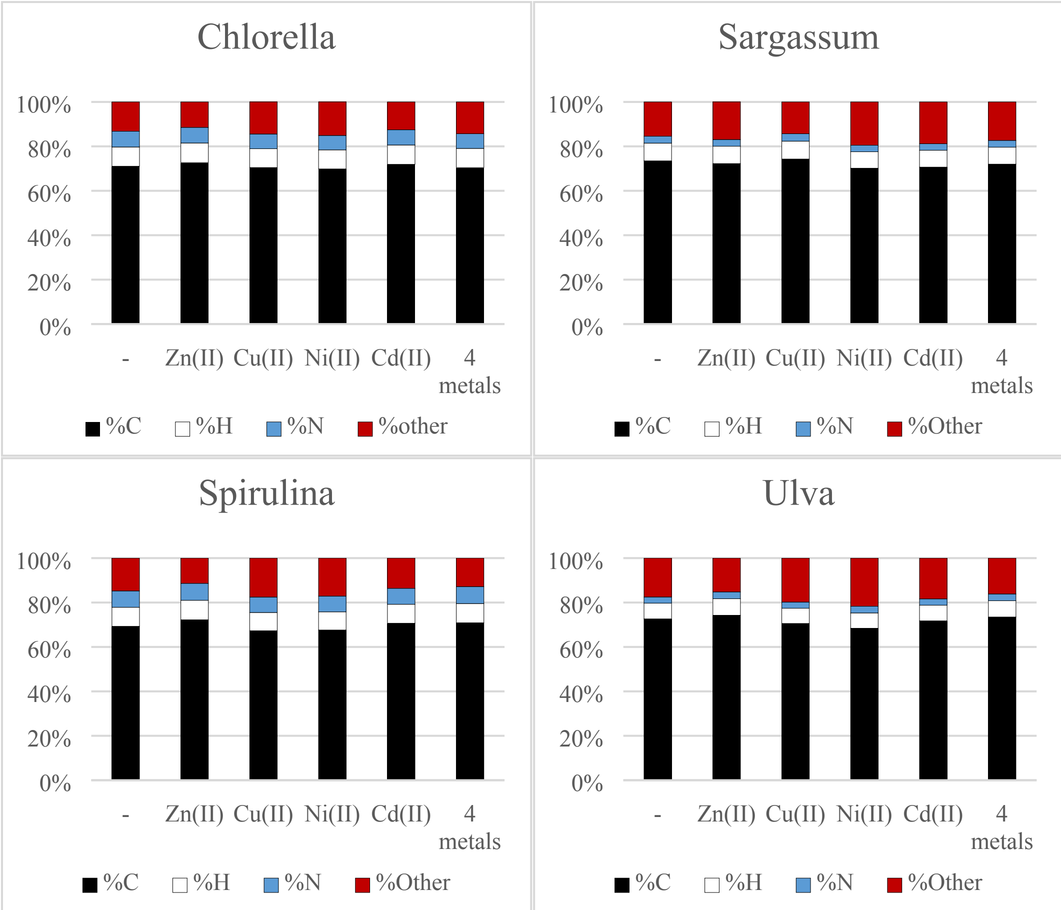

Figure S3. Elemental analysis of the bio-crudes produced from the HTL of the algal biomass on bioabsorption of the metals

Table S2 Higher heating values and energy recovery for bio-crudes produced from the four feedstocks with increasing amount of target metals added

Feedstock	Metal concentration	HHV (calc.) MJ/kg	Energy recovery %
Chlorella	0 mM	33.5	56.7
Chlorella	10 mM	33.7	58.2
Chlorella	50 mM	31.8	59.9
Chlorella	150 mM	32.8	55.7
Spirulina	0 mM	32.6	46.8
Spirulina	10 mM	32.0	48.3
Spirulina	50 mM	31.4	48.4
Spirulina	150 mM	31.8	48.3
Sargassum	0 mM	33.4	18.7
Sargassum	10 mM	33.6	21.5
Sargassum	50 mM	32.2	20.5
Sargassum	150 mM	30.8	18.7
Ulva	0 mM	31.9	31.9
Ulva	10 mM	29.9	33.0
Ulva	50 mM	31.3	30.8
Ulva	150 mM	31.4	31.6

Table S3 Standard error associated with the experimental design

Fraction		Chlorella	Spirulina	Sargassum	Ulva
Biocrude	Mean (g)	***1.58***	***1.26***	***0.36***	***0.52***
	Std Dev	*0.04*	*0.07*	*0.07*	*0.02*
	Std error	*0.03*	*0.04*	*0.04*	*0.01*
	Error %	*1.6*	*3.3*	*10.5*	*1.9*
Aq phase	Mean (g)	***17.8***	***17.5***	***13.5***	***15.7***
	Std Dev	*0.8*	*0.4*	*0.3*	*0.7*
	Std error	*0.45*	*0.23*	*0.18*	*0.38*
	Error %	*2.5*	*1.3*	*1.3*	*2.4*
Gas	Mean (ml)	***257***	***263***	***406***	***289***
	Std Dev	*12*	*36*	*10*	*19*
	Std error	*6.67*	*20.83*	*5.55*	*10.73*
	Error %	*2.6*	*7.9*	*1.4*	*3.7*
Solid	Mean (g)	***0.26***	***0.30***	***1.40***	***0.88***
	Std Dev	*0.05*	*0.04*	*0.02*	*0.13*
	Std error	*0.03*	*0.02*	*0.01*	*0.07*
	Error %	*11.6*	*8.2*	*0.9*	*8.5*

Table S4 Concentration of salts used in this study

METAL	AW	METAL SALT	FW	solution	metal conc.	metal conc.	metal conc.
	g/mol		g/mol		mmol/L	mg salt/L	mg metal/L = ppm
Zn	65.39	$ZnSO_4$ $7H_2O$	287.56	single metal (10 mM), with biosorption	10	2875.6	653.9
Cu	63.546	$CuSO_4$ $5H_2O$	249.69	single metal (10 mM), with biosorption	10	2496.9	635.46
Ni	58.6934	$NiSO_4$ $6H_2O$	262.85	single metal (10 mM), with biosorption	10	2628.5	586.934
Cd	112.414	$CdSO_4$ 8/3 H_2O	256.57	single metal (10 mM), with biosorption	10	2565.7	1124.14
Zn	65.39	$ZnSO_4$ $7H_2O$	287.56	4 metals (10 mM tot), with and without biosorption	2.5	718.9	163.475
Cu	63.546	$CuSO_4$ $5H_2O$	249.69	4 metals (10 mM tot), with and without biosorption	2.5	624.225	158.865
Ni	58.6934	$NiSO_4$ $6H_2O$	262.85	4 metals (10 mM tot), with and without biosorption	2.5	657.125	146.7335
Cd	112.414	$CdSO_4$ 8/3 H_2O	256.57	4 metals (10 mM tot), with and without biosorption	2.5	641.425	281.035
Zn	65.39	$ZnSO_4$ $7H_2O$	287.56	4 metals (50 mM tot), without biosorption	12.5	3594.5	817.375
Cu	63.546	$CuSO_4$ $5H_2O$	249.69	4 metals (50 mM tot), without biosorption	12.5	3121.125	794.325
Ni	58.6934	$NiSO_4$ $6H_2O$	262.85	4 metals (50 mM tot), without biosorption	12.5	3285.625	733.6675
Cd	112.414	$CdSO_4$ 8/3 H_2O	256.57	4 metals (50 mM tot), without biosorption	12.5	3207.125	1405.175
Zn	65.39	$ZnSO_4$ $7H_2O$	287.56	4 metals (150 mM tot), without biosorption	37.5	10783.5	2452.125
Cu	63.546	$CuSO_4$ $5H_2O$	249.69	4 metals (150 mM tot), without biosorption	37.5	9363.375	2382.975
Ni	58.6934	$NiSO_4$ $6H_2O$	262.85	4 metals (150 mM tot), without biosorption	37.5	9856.875	2201.0025
Cd	112.414	$CdSO_4$ 8/3 H_2O	256.57	4 metals (150 mM tot), without biosorption	37.5	9621.375	4215.525