

Supporting Information for

Assessment of the applied potential of sludge-derived hydrochar in terms of process parameters and product properties

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Table S1 Basic properties of AS and DS.

| Samples | Moisture (%) | Ash (wt%, db) | Elemental analysis (wt%, db) ^a | | | | | HHV ^b (MJ/kg) | R ₅₀ |
|---------|--------------|---------------|---|-----|------|-----|-----|--------------------------|-----------------|
| | | | C | H | O | N | S | | |
| AS | 98.4 | 46.9 | 26.8 | 4.4 | 16.8 | 4.6 | 0.5 | 11.87 | 0.45 |
| DS | 80.3 | 48.2 | 25.4 | 4.5 | 17.3 | 4.2 | 0.5 | 11.37 | 0.44 |

| Samples | Heavy metal (mg/g) ^c | | | |
|---------|---------------------------------|--------|--------|--------|
| | Zn | Cu | Ni | Cr |
| AS | 0.2311 | 0.1422 | 0.0129 | 0.0025 |
| DS | 0.1840 | 0.2158 | 0.0148 | 0.0086 |

Note:

^a Determined by elemental analysis using the combustion method and O (Oxygen) was calculated by difference based on dry basis.

^b HHV, higher heating value and $HHV=0.349C+1.1783H+0.1005S-0.1034O-0.0015N-0.0211A$.

^c Determined by ICP-OES.

Table S2 Atomic ratio of AS-HCs and DS-HCs.

| Sample | H/C | O/C | (O+N)/C | C/N | R ₅₀ | HHV(MJ/kg) | LHV(kJ/kg) |
|-------------|------|------|---------|-------|-----------------|------------|------------|
| AS | 1.99 | 0.47 | 0.62 | 6.73 | 0.45 | 11.87 | 9.57 |
| AS-HC-180-1 | 2.23 | 0.47 | 0.59 | 8.57 | 0.38 | 8.85 | 7.08 |
| AS-HC-180-2 | 2.07 | 0.41 | 0.50 | 11.91 | 0.39 | 7.29 | 6.25 |
| AS-HC-180-3 | 2.10 | 0.39 | 0.47 | 11.86 | 0.39 | 7.73 | 6.46 |
| AS-HC-180-4 | 2.06 | 0.42 | 0.50 | 12.35 | 0.40 | 6.81 | 5.96 |
| AS-HC-220-1 | 2.11 | 0.42 | 0.51 | 11.70 | 0.40 | 6.93 | 5.95 |
| AS-HC-220-2 | 2.15 | 0.39 | 0.47 | 12.68 | 0.39 | 7.08 | 5.97 |
| AS-HC-220-3 | 1.97 | 0.30 | 0.36 | 15.83 | 0.42 | 6.79 | 5.92 |
| AS-HC-220-4 | 1.96 | 0.34 | 0.40 | 16.42 | 0.42 | 6.05 | 5.49 |
| AS-HC-260-1 | 2.01 | 0.35 | 0.42 | 15.74 | 0.42 | 5.98 | 5.40 |
| AS-HC-260-2 | 1.90 | 0.31 | 0.37 | 16.65 | 0.43 | 5.59 | 5.23 |
| AS-HC-260-3 | 1.88 | 0.29 | 0.35 | 17.15 | 0.44 | 5.97 | 5.50 |
| AS-HC-260-4 | 1.78 | 0.34 | 0.39 | 19.25 | 0.43 | 5.86 | 5.60 |
| DS | 2.11 | 0.51 | 0.65 | 7.04 | 0.44 | 11.37 | 9.02 |
| DS-HC-180-1 | 2.04 | 0.48 | 0.60 | 8.28 | 0.39 | 11.62 | 9.32 |
| DS-HC-180-2 | 1.94 | 0.45 | 0.60 | 7.04 | 0.40 | 11.50 | 9.47 |
| DS-HC-180-3 | 1.85 | 0.37 | 0.48 | 9.14 | 0.40 | 9.33 | 7.96 |
| DS-HC-180-4 | 1.90 | 0.42 | 0.54 | 8.25 | 0.38 | 9.37 | 7.95 |
| DS-HC-220-1 | 2.00 | 0.45 | 0.58 | 7.58 | 0.40 | 11.06 | 8.94 |
| DS-HC-220-2 | 1.80 | 0.27 | 0.37 | 10.38 | 0.42 | 9.33 | 7.87 |
| DS-HC-220-3 | 1.79 | 0.33 | 0.42 | 10.70 | 0.41 | 8.99 | 7.75 |
| DS-HC-220-4 | 1.75 | 0.28 | 0.36 | 11.50 | 0.42 | 9.23 | 7.92 |
| DS-HC-260-1 | 1.79 | 0.27 | 0.36 | 10.86 | 0.41 | 9.14 | 7.77 |
| DS-HC-260-2 | 1.74 | 0.25 | 0.33 | 12.07 | 0.43 | 8.92 | 7.68 |
| DS-HC-260-3 | 1.67 | 0.20 | 0.28 | 13.24 | 0.44 | 8.60 | 7.50 |
| DS-HC-260-4 | 1.72 | 0.19 | 0.27 | 12.52 | 0.44 | 8.81 | 7.55 |

Note: Atomic ratio is based on the elemental analysis result. The O/C: the atomic ratio of oxygen to carbon. (O+N)/C: the atomic ratio of the sum of nitrogen and oxygen to carbon. H/C: the atomic ratio of hydrogen to carbon. C/N: the atomic ratio of carbon to nitrogen. HHV: higher heating value; LHV: Lower heating value.

Table S3 Parameters on process energy of DS-HCs.

| Parameters | DS-180-2 | DS-220-2 | DS-260-4 |
|-----------------------------------|----------|----------|----------|
| Vapor Pressure(Mpa) | 1.0 | 2.3 | 4.7 |
| Vapor Density(kg/m ³) | 5.1 | 11.6 | 23.8 |
| Vapor Mass(kg) | 16.1 | 36.3 | 74.6 |
| Required Energy(MJ) at 80.3% | 2785 | 3530 | 4306 |
| Recovery Energy from HCs(MJ) | 5337 | 5113 | 4308 |

Note: Vapor Pressure= P(T); Vapor Mass=q_s; Required Energy=Q.

Table S4 The content of heavy metals in AS-HCs and DS-HCs.

| Sample | Zn (mg/g) | Cu (mg/g) | Ni (mg/g) | Cr (mg/g) |
|-------------|-----------|-----------|-----------|-----------|
| AS | 0.2311 | 0.1422 | 0.0129 | 0.0025 |
| AS-HC-180-1 | 0.4025 | 0.1010 | 0.0214 | 0.0143 |
| AS-HC-180-2 | 0.3320 | 0.0518 | 0.0192 | 0.0060 |
| AS-HC-180-3 | 0.6317 | 0.0716 | 0.0214 | 0.0112 |
| AS-HC-180-4 | 0.3673 | 0.1408 | 0.0211 | 0.0088 |
| AS-HC-220-1 | 0.4807 | 0.1080 | 0.0225 | 0.0171 |
| AS-HC-220-2 | 0.4764 | 0.1004 | 0.0205 | 0.0148 |
| AS-HC-220-3 | 0.5043 | 0.1346 | 0.0224 | 0.0151 |
| AS-HC-220-4 | 0.3548 | 0.0436 | 0.0184 | 0.0022 |
| AS-HC-260-1 | 0.4793 | 0.1554 | 0.0233 | 0.0201 |
| AS-HC-260-2 | 0.4838 | 0.1520 | 0.0199 | 0.0208 |
| AS-HC-260-3 | 0.5510 | 0.0997 | 0.0219 | 0.0175 |
| AS-HC-260-4 | 0.5019 | 0.1141 | 0.0253 | 0.0188 |
| DS | 0.1840 | 0.2158 | 0.0148 | 0.0086 |
| DS-HC-180-1 | 0.2819 | 0.2526 | 0.0148 | 0.0042 |
| DS-HC-180-2 | 0.2757 | 0.1369 | 0.0142 | 0.0041 |
| DS-HC-180-3 | 0.2277 | 0.1467 | 0.0175 | ND |
| DS-HC-180-4 | 0.2830 | 0.0823 | 0.0164 | 0.0012 |
| DS-HC-220-1 | 0.2390 | 0.2125 | 0.0138 | 0.0095 |
| DS-HC-220-2 | 0.2576 | 0.1403 | 0.0172 | 0.0059 |
| DS-HC-220-3 | 0.3157 | 0.1747 | 0.0159 | 0.0051 |
| DS-HC-220-4 | 0.3013 | 0.2201 | 0.0171 | 0.0036 |
| DS-HC-260-1 | 0.2694 | 0.0985 | 0.0150 | 0.0011 |
| DS-HC-260-2 | 0.2970 | 0.1821 | 0.0192 | 0.0084 |
| DS-HC-260-3 | 0.3153 | 0.1984 | 0.0250 | 0.0156 |
| DS-HC-260-4 | 0.3002 | 0.1710 | 0.0225 | 0.0152 |

Note: ND represent not determined.

Cd content were below the detection limit in all samples.

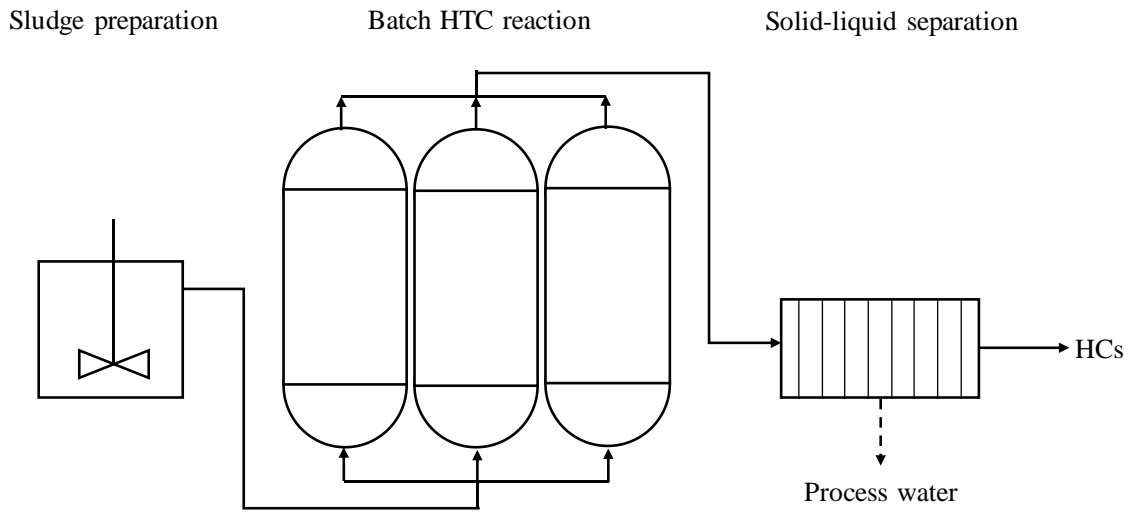


Fig.S1 Schematic diagram of HTC process.