

Supplementary material for:

Fate of heavy metals in industrially relevant pyrolysis of diverse contaminated organic
wastes: phase partitioning and pH-dependent leaching

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Section SA: Development of pH-dependent leaching test

Biochars have complex buffering capacities, in which inorganic phases (ash) are thought to quickly neutralize excess H^+ while oxygenated functional groups act more slowly (Berek & Hue, 2016). Furthermore, feedstock type and pyrolysis conditions affect biochar composition in terms of ash content and surface functional groups (Martinsen et al., 2015). Initial testing showed that the biochars' response to acid added would vary greatly; upon adding 0.0004 mol of H^+ pH would change by 1-3 units during the course of 24hrs. Thus, keeping the pH stable at a specific level for the duration of a leaching test was not trivial. Method development was required to determine the best time scale to perform the leaching test on.

Titration curves for different time intervals were constructed for each of the CWC (4x), WT (4x), DSS-1 (4x) and DSS-2 (4x) biochars (total 16 samples) by adding different doses of HCl (1 M; 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.5, 2.5, 2.6, 2.8, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6.0 mL) to 20 parallel vials (25 mL) with biochar and H_2O (DI, 18M Ω) at a 1:5 ratio. pH was subsequently measured at seven separate time intervals (4, 8, 24, 48, 72, 144 and 192 hrs). The resulting titration curves for each biochars were plotted at the different time intervals. See Figure S.2 for selected examples. From the titration curves it was established that negligible changes in pH were observed at time intervals ≥ 72 hrs.

The titration curves for the 72 hr time series for each of the 16 individual samples were hence used to estimate the number of moles of H^+ needed to lower biochar pH to 4, 5.5 and 7 respectively.

Section SB – Supporting tables and figures

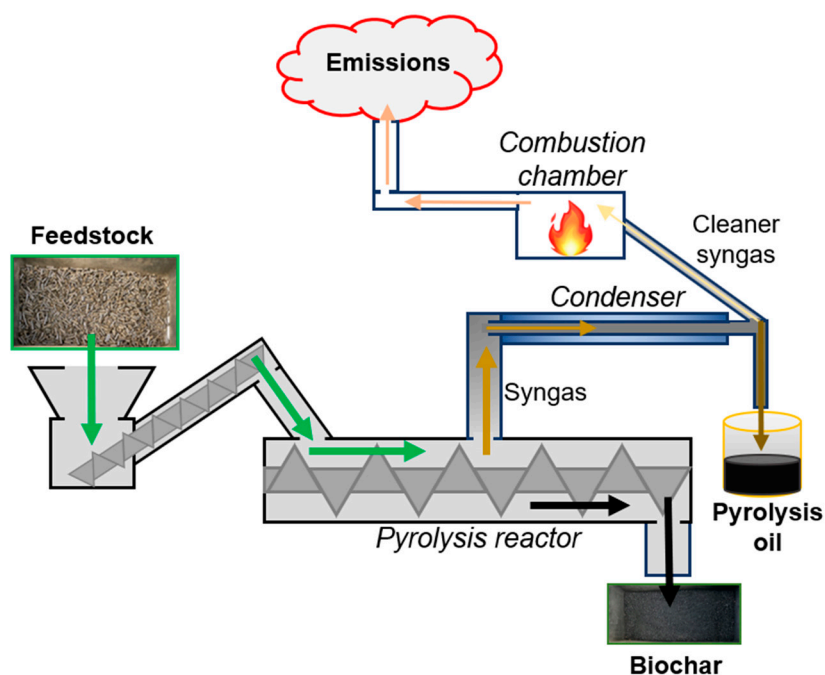


Figure S.1. Schematic of the Biogreen pyrolysis system (adapted from Sørmo et al, (2023)).

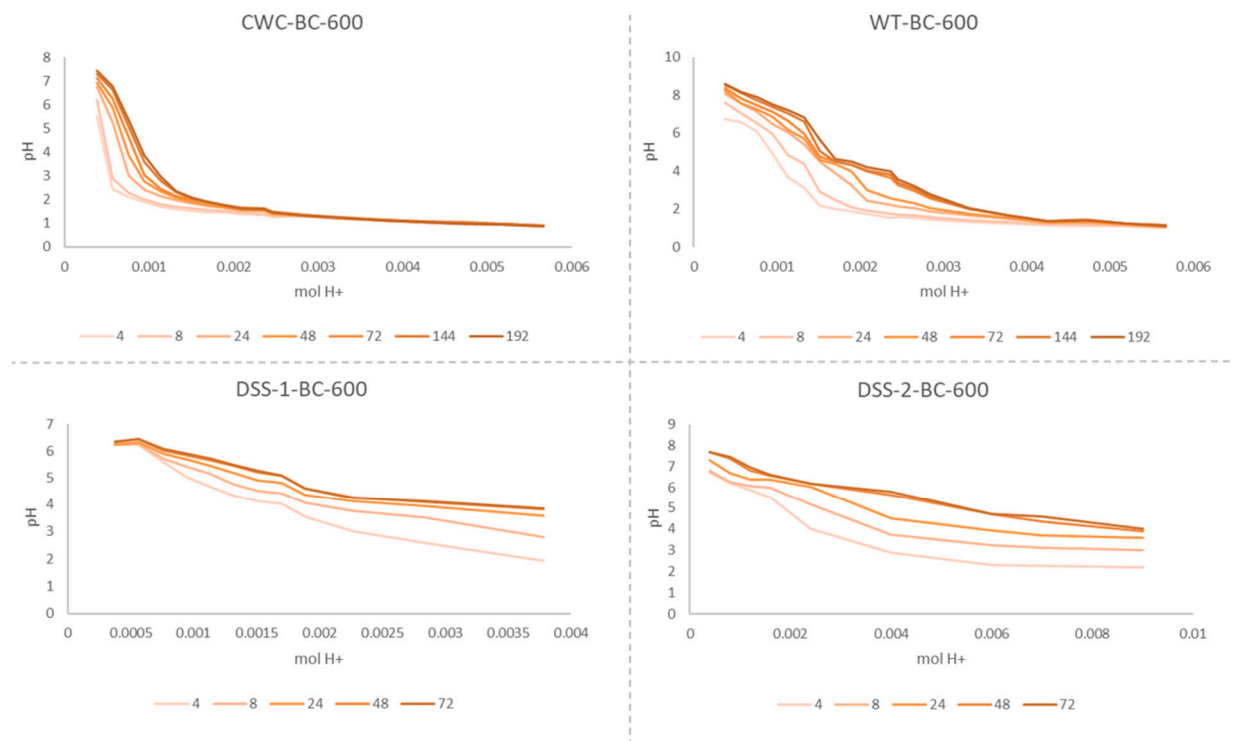
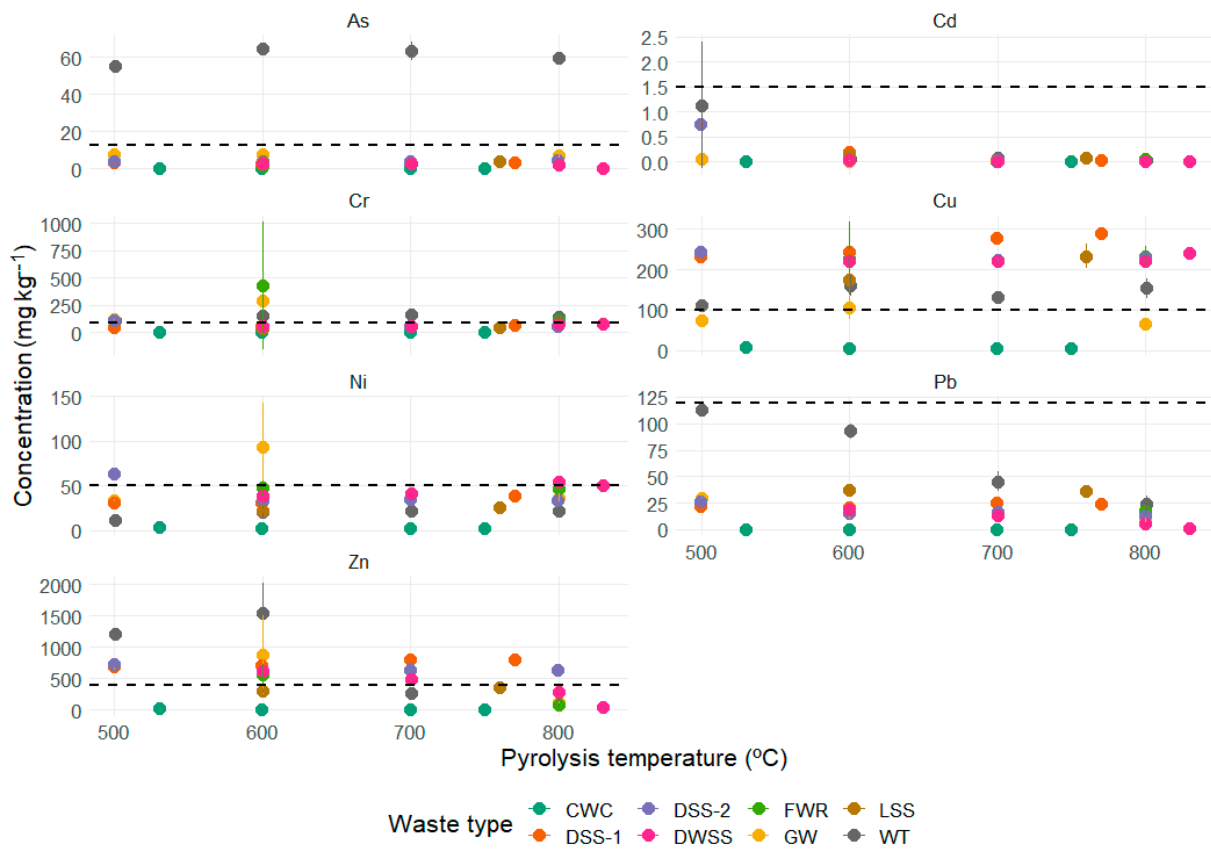


Figure S.2. Titration curves for CWC, WT, DSS-1, DSS-2 biochars produced at 600 C, repeated for different time intervals (4, 8, 24, 48, 72, 144, 192 hrs).

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11 *Figure S.3. Concentrations of As, Cd, Cr, Cu, Ni, Pb and Zn (mg kg^{-1}) in biochars produced from*
 12 *waste feedstocks at pyrolysis temperatures between 500 and 800 $^{\circ}\text{C}$ ($n=3$). CWC = clean wood chips,*
 13 *WT = waste timber, GW = garden waste, FWR = food waste reject, DSS-1 and DSS-2 = digested*
 14 *sewage sludge, LSS = limed sewage sludge, and DWSS = de-watered sewage sludge. Dashed lines*
 15 *indicate threshold levels based on the EBC-agro quality criteria*

Table S.1: Concentrations of trace elements ($n=3$, mg kg^{-1}) in feedstocks (0) and biochars produced at different pyrolysis temperatures (500-800 °C). Data for both HNO_3 , and HNO_3+HF digestions.

| Feedstock | Pyr. Temp (°C) | As | | Ba | | Cd | | Co | | Cr | | Cu | | Mo | | Ni | | Pb | | Sr | | V | | Zn | |
|-----------|----------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|
| | | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF | HNO_3 | HNO_3+HF |
| CWC | 0 | 0.033±0.0003 | N/A | 41±2 | N/A | 0.059±0.002 | N/A | 0.055±0.002 | N/A | 0.08±0.03 | N/A | 0.88±0.01 | N/A | 0.008 | N/A | 0.18±0.02 | N/A | 0.13±0.02 | N/A | 7.1±0.1 | N/A | 0.029±0.003 | N/A | 23±2 | N/A |
| | 530 | 0.02±0.01 | N/A | 187±12 | N/A | 0.0006±0.0003 | N/A | 0.30±0.06 | N/A | 5±3 | N/A | 7±4 | N/A | 0.13 | N/A | 4±2 | N/A | 0.15±0.09 | N/A | 33±2 | N/A | 0.11±0.02 | N/A | 26±4 | N/A |
| | 600 | 0.014±0.005 | N/A | 233±21 | N/A | 0.0007 | N/A | 0.33±0.03 | N/A | 3±3 | N/A | 4.9±0.4 | N/A | 0.08 | N/A | 3±1 | N/A | 0.06±0.01 | N/A | 37±3 | N/A | 0.100±0.009 | N/A | 12.7±0.6 | N/A |
| | 700 | 0.011±0.003 | N/A | 217±6 | N/A | 0.0004 | N/A | 0.30±0.03 | N/A | 2±1 | N/A | 5.2±0.6 | N/A | 0.06 | N/A | 1.8±0.6 | N/A | 0.08±0.02 | N/A | 36±2 | N/A | 0.10±0.02 | N/A | 3.2±0.6 | N/A |
| | 750 | 0.015±0.004 | N/A | 237±6 | N/A | 0.0011±0.0001 | N/A | 0.323±0.006 | N/A | 1.6±0.9 | N/A | 5.1±0.2 | N/A | 0.06 | N/A | 1.9±0.3 | N/A | 0.3±0.4 | N/A | 40±2 | N/A | 0.11±0.01 | N/A | 2.8±0.1 | N/A |
| WT | 0 | 18±1 | 16.7±0.6 | 124±1 | 120±6 | 0.61±0.04 | 0.609±0.006 | 2.9±0.2 | 2.9±0.1 | 37±3 | 34±2 | 32±2 | 35±1 | 0.62±0.03 | 1.01±0.06 | 6.2±0.4 | 6±1 | 37±1 | 33±2 | 32.3±0.6 | 36±1 | 2.0±0.1 | 2.3±0.1 | 491±15 | 546±67 |
| | 500 | 55±2 | 55±3 | 373±6 | 383±12 | 1±1 | 0.41±0.04 | 7.5±0.2 | 7.6±0.2 | 107±6 | 113±6 | 110±1 | 156±45 | 0.64±0.02 | 1.97±0.06 | 11.0±0.1 | 26±22 | 113±6 | 110.0±0.1 | 98±2 | 109.8±0.1 | 6.3±0.2 | 7.1±0.1 | 1200±1 | 1299±100 |
| | 600 | 64±4 | 61±5 | 477±25 | 539±35 | 0.048±0.007 | 0.058±0.005 | 9.7±0.4 | 11±3 | 153±25 | 133±15 | 160±26 | 176±40 | 0.70±0.04 | 2.0±0.5 | 20±7 | 19±3 | 93±8 | 102±6 | 127±6 | 139.8±0.1 | 7.1±0.4 | 10±1 | 1533±493 | 1332±58 |
| | 700 | 63±5 | 65±2 | 537±12 | 626±21 | 0.069±0.006 | 0.069±0.003 | 11.0±0.1 | 11.6±0.6 | 163±12 | 163±12 | 130±10 | 146±12 | 0.79±0.03 | 2.0±0.1 | 22±6 | 22±4 | 45±9 | 50±8 | 150.0±0.1 | 159.8±0.1 | 9.1±0.9 | 9.3±0.4 | 263±23 | 312±49 |
| | 800 | 59±2 | 60±6 | 583±15 | 679±1 | 0.023±0.002 | 0.030±0.005 | 11.3±0.6 | 13.0±0.1 | 137±15 | 143±15 | 153±25 | 140±10 | 0.447±0.006 | 2.0±0.1 | 21±5 | 21±3 | 24±7 | 22±5 | 150.0±0.1 | 180±10 | 8.7±0.5 | 11±2 | 108±62 | 83±4 |
| GW | 0 | 2.3±0.4 | 2.2±0.2 | 34±3 | 57±6 | 0.268±0.006 | 0.28±0.02 | 1.68±0.06 | 1.76±0.06 | 40±4 | 29±2 | 16±2 | 19±1 | 2.7±0.3 | 2.6±0.2 | 15±2 | 13±1 | 6±2 | 5.1±0.1 | 29.5±0.6 | 41±1 | 5.7±0.2 | 6.4±0.3 | 121±1 | 124±6 |
| | 500 | 7.9±0.3 | 8.7±0.5 | 120±1 | 190±10 | 0.049±0.006 | 0.056±0.003 | 6.1±0.1 | 6.6±0.3 | 113±6 | 92±16 | 75±2 | 105±24 | 5.5±0.2 | 6.3±0.3 | 33±1 | 38±5 | 30±1 | 32±2 | 99±1 | 133±6 | 30±1 | 35±1 | 690±53 | 2547±2901 |
| | 600 | 7.9±0.2 | 7.4±0.1 | 133±6 | 210±10 | 0.013±0.004 | 0.019±0.005 | 7±1 | 6.3±0.1 | 290±85 | 173±6 | 105±28 | 119±69 | 20±10 | 10.6±0.6 | 93±50 | 47±2 | 15±5 | 15±2 | 110.0±0.1 | 143±6 | 29.3±0.6 | 33.6±0.6 | 877±627 | 1817±1983 |
| | 800 | 7±1 | 8±2 | 133±6 | 197±6 | 0.0105±0.0005 | 0.03±0.04 | 5.3±0.2 | 5.5±0.2 | 104±11 | 80±4 | 64±7 | 443±655 | 6.2±0.7 | 6.3±0.6 | 36±5 | 41±8 | 9±2 | 32±30 | 120.0±0.1 | 140.0±0.1 | 20.3±0.6 | 27.6±0.6 | 109±18 | 387±450 |
| FWR | 0 | 1.03±0.07 | 1.7±0.5 | 131±10 | 128±12 | 0.18±0.04 | 0.19±0.05 | 6.0±0.4 | 7.8±0.8 | 91±7 | 99±50 | 384±348 | 254±40 | 5.7±0.3 | 6.1±0.3 | 39±1 | 58±31 | 9.0±0.8 | 10±2 | 145±15 | 92±3 | 5.1±0.2 | 7.3±0.8 | 434±122 | 468±50 |
| | 600 | 1.7±0.1 | 3.5±0.1 | 263±110 | 133±6 | 0.033±0.004 | 0.1±0.2 | 16±2 | 16±3 | 427±583 | 54±4 | 227±91 | 349±70 | 6.4±0.4 | 7.4±0.6 | 47±9 | 47±4 | 16±4 | 30±4 | 243±101 | 190±20 | 13±2 | 17±1 | 557±180 | 937±10 |
| | 800 | 1.9±0.2 | 3.7±0.3 | 267±15 | 140±10 | 0.049±0.004 | 0.03±0.04 | 17±6 | 16±2 | 109±19 | 86±56 | 233±25 | 549±349 | 7.1±0.3 | 8.2±0.9 | 46±3 | 80±41 | 17±4 | 17.6±0.6 | 267±21 | 187±15 | 15±1 | 18±2 | 75±4 | 141±15 |
| DSS-1 | 0 | 6.0±0.2 | 7.5±0.3 | 124±6 | 114±6 | 0.59±0.02 | 0.61±0.04 | 6.2±0.2 | 6.7±0.2 | 34±2 | 23±1 | 150±1 | 169±1 | 17±1 | 20.3±0.6 | 20.7±0.6 | 20.2±0.6 | 14.0±0.1 | 15.3±0.6 | 82±2 | 84.5±0.6 | 36±1 | 44±1 | 451±10 | 485±15 |
| | 500 | 3.2±0.2 | 4.6±0.1 | 150±1 | 136±6 | 0.74±0.08 | 0.64±0.01 | 8.1±0.4 | 8.6±0.2 | 48±4 | 35±2 | 233± | 222±6 | 16.7±0.6 | 17.6±0.6 | 30.3±0.6 | 31±3 | 22±2 | 21.2±0.6 | 103±6 | 95±4 | 46±2 | 49.6±0.6 | 690±10 | 716±15 |
| | 600 | 2.9±0.2 | 4.6±0.1 | 157±6 | 126±6 | 0.197±0.006 | 0.3±0.1 | 8.6±0.1 | 8.9±0.3 | 50±5 | 39±5 | 243±6 | 229±1 | 16.3±0.6 | 18.6±0.6 | 31±2 | 34±2 | 21.0±0.1 | 21.2±0.6 | 110.0±0.1 | 94±5 | 47±1 | 50.9±0.1 | 707±21 | 743±12 |
| | 700 | 3.1±0.2 | 5.1±0.1 | 177±6 | 143±6 | 0.029±0.003 | 0.040±0.008 | 9.97±0.06 | 9.8±0.2 | 53±2 | 38±5 | 277±6 | 259±1 | 19.0±0.1 | 21.0±0.1 | 34.7±0.6 | 35±2 | 25±4 | 25±1 | 120.0±0.1 | 106±6 | 54±1 | 57.3±0.6 | 797±6 | 833±23 |
| | 770 | 3.5±0.3 | 5.0±0.2 | 180±1 | 170±1 | 0.026±0.002 | 0.027±0.008 | 11.0±0.1 | 10.0±0.1 | 62±1 | 41±2 | 290±1 | 266±6 | 19.7±0.6 | 21.0±0.1 | 39.3±0.6 | 38±2 | 24±1 | 26±1 | 130.0±0.1 | 113±6 | 56±1 | 58.6±0.6 | 797±15 | 829±30 |
| DSS-2 | 0 | 2.23±0.06 | 2.17±0.06 | 101.9±0.6 | 58±3 | 0.51±0.01 | 0.51±0.02 | 3.9±0.1 | 4.1±0.1 | 25±2 | 17.4±0.6 | 115±1 | 124±1 | 6.4±0.1 | 6.4±0.1 | 17±1 | 15.0±0.1 | 8.0±0.1 | 8.1±0.1 | 52±1 | 24±3 | 18.8±0.1 | 19.8±0.1 | 302±1 | 331±1 |
| | 500 | 3.8±0.1 | 3.7±0.2 | 197±6 | 110±1 | 0.74±0.02 | 0.78±0.07 | 7.2±0.2 | 7.4±0.2 | 110.0±0.1 | 75±8 | 243±15 | 229±10 | 12.0±0.1 | 12.3±0.6 | 64±2 | 62±3 | 26±3 | 28±2 | 97±3 | 53±3 | 35±1 | 33.9±0.1 | 723±51 | 879±137 |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|------|-----|-----------|-----------|--------|--------|-------------|-------------|-----------|-----------|----------|----------|-----------|--------|----------|----------|----------|----------|----------|----------|-----------|-----------|----------|----------|--------|--------|
| | 600 | 4.13±0.06 | 4.0±0.1 | 210±1 | 120±17 | 0.087±0.005 | 0.09±0.02 | 7.4±0.1 | 7.4±0.2 | 52.3±0.6 | 39±5 | 220±1 | 206±6 | 11.7±0.6 | 12.6±0.6 | 34.1±0.1 | 37±3 | 15.7±0.6 | 16.2±0.6 | 103±6 | 60±11 | 39.3±0.6 | 38.6±0.6 | 620±10 | 656±23 |
| | 700 | 4.17±0.06 | 4.1±0.2 | 217±6 | 133±23 | 0.024±0.003 | 0.02±0.01 | 7.7±0.3 | 7.4±0.2 | 51±1 | 37±4 | 223±6 | 202±6 | 11.7±0.6 | 13.3±0.6 | 34.3±0.6 | 38±2 | 16.0±0.1 | 15.6±0.6 | 110.0±0.1 | 66±8 | 39±1 | 39±1 | 630±10 | 653±6 |
| | 800 | 4.37±0.06 | 4.0±0.2 | 220±1 | 130±1 | 0.009±0.002 | 0.01±0.01 | 7.4±0.2 | 7.9±0.2 | 51±2 | 35±1 | 230±1 | 222±6 | 12.3±0.6 | 14.0±0.1 | 34±2 | 38±2 | 13.0±0.1 | 12.9±0.1 | 110.0±0.1 | 66±2 | 40±1 | 41.3±0.6 | 640±10 | 666±15 |
| LSS | 0 | 2.2±0.1 | 2.27±0.06 | 125±1 | 71±6 | 0.59±0.01 | 0.59±0.02 | 2.7±0.1 | 2.9±0.1 | 23.6±0.6 | 6.4±0.8 | 212±6 | 238±1 | 4.6±0.2 | 5.0±0.1 | 16.0±0.1 | 14.4±0.6 | 26.1±0.1 | 26±1 | 177.0±0.1 | 64±10 | 17.4±0.6 | 19.4±0.6 | 333±1 | 358±6 |
| | 600 | 3.2±0.2 | 3.2±0.2 | 123±12 | 177±21 | 0.11±0.01 | 0.10±0.02 | 3.9±0.2 | 4.2±0.1 | 38±6 | 16±3 | 173±21 | 299±10 | 7.1±0.5 | 7.3±0.3 | 22±3 | 23±2 | 37±2 | 38±1 | 163±21 | 160±26 | 27±2 | 29.3±0.6 | 303±29 | 534±12 |
| | 760 | 3.87±0.06 | 3.68±0.06 | 170±20 | 190±1 | 0.06±0.05 | 0.006±0.008 | 4.5±0.1 | 4.9±0.1 | 38.3±0.6 | 7.1±0.1 | 233±31 | 365±6 | 8.2±0.1 | 8.2±0.1 | 25.7±0.6 | 24.8±0.6 | 36.0±0.1 | 36.6±0.6 | 220±26 | 120.0±0.1 | 33.0±0.1 | 34.0±0.1 | 363±47 | 571±12 |
| DWSS | 0 | 1.67±0.06 | 1.7±0.1 | 133±1 | 74±3 | 0.53±0.01 | 0.55±0.01 | 3.23±0.06 | 3.28±0.06 | 31±3 | 20.4±0.1 | 101.7±0.6 | 111±1 | 3.9±0.2 | 3.9±0.2 | 20±1 | 16.5±0.6 | 8.9±0.1 | 9.5±0.1 | 39.4±0.6 | 19.7±0.6 | 15.3±0.1 | 15.6±0.6 | 279±6 | 293±10 |
| | 600 | 2.7 | 2.7 | 300 | 220 | 0.032 | 0.034 | 6.8 | 7.1 | 58 | 58 | 220 | 230 | 6.7 | 7.2 | 39 | 41 | 18 | 19 | 89 | 61 | 35 | 34 | 610 | 640 |
| | 700 | 3 | 3 | 310 | 140 | 0.008 | 0.012 | 7.1 | 7.3 | 56 | 53 | 220 | 240 | 7.1 | 7.8 | 41 | 42 | 13 | 14 | 87 | 32 | 34 | 36 | 480 | 500 |
| | 800 | 2 | 2 | 300 | 280 | 0.010 | 0.012 | 7.7 | 8.1 | 75 | 73 | 220 | 240 | 10 | 8.4 | 54 | 49 | 4.9 | 6.6 | 92 | 78 | 35 | 37 | 290 | 330 |
| | 830 | 0.46 | 0.46 | 310 | 420 | 0.003 | 0.003 | 8.2 | 8 | 76 | 71 | 240 | 260 | 8.2 | 8.3 | 51 | 49 | 0.8 | 1.8 | 97 | 120 | 38 | 38 | 36 | 43 |
| | LOD | 0.001 | 0.04 | 0.2 | 1 | 0.005 | 0.001 | 0.003 | 0.010 | 0.08 | 0.3 | 0.2 | 1.0 | 0.004 | 0.075673 | 0.02 | 0.2 | 0.07 | 0.05 | 0.07 | 0.4 | 0.002 | 0.01 | 4 | 0.5 |
| | LOQ | 0.004 | 0.1 | 0.6 | 5 | 0.02 | 0.004 | 0.01 | 0.03 | 0.3 | 1 | 0.5 | 3 | 0.01 | 0.3 | 0.07 | 0.8 | 0.2 | 0.2 | 0.2 | 1 | 0.006 | 0.04 | 13 | 2 |

Table S.2: Characterization data including pH, conductivity, ash, C, H, N and main elements for the feedstocks investigated and the resulting biochars.

| Feedstock | Pyr. temp. | pH | Biochar Yield | Conductivity | Ash | C | H | N | Al | Ca | Fe | K | Mg | Na | P | S | Si |
|-----------|---------------|------------|------------------|-----------------------|------|------------|-----------|-----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | °C | (-) | (%) | $\mu\text{S cm}^{-1}$ | % | % | % | % | g kg^{-1} | g kg^{-1} | g kg^{-1} | g kg^{-1} | g kg^{-1} | g kg^{-1} | g kg^{-1} | g kg^{-1} | g kg^{-1} |
| DSS-1 | 0 | - | - | - | - | 20.46±0.03 | 3.63±0.03 | 2.45±0 | 0.035±0.001 | 16.0±0 | 130±0 | 2.77±0.06 | 3.13±0.06 | 1.3±0 | 3±1 | 4.6±0.4 | 31±1 |
| | 500 | 8.1±0.3 | 62.2 | 2.2±0.1 | 70.7 | 13.2±0.1 | 1.8±0.1 | 1.39±0.02 | 0.055±0.002 | 22.3±0.6 | 167±6 | 3.33±0.06 | 4.2±0.1 | 1.37±0.06 | 12±2 | 8.1±0.9 | 29±5 |
| | 600 | 8.1±0.2 | 58.4 | 2.5±0.1 | 75.2 | 13.1±0 | 1.58±0.05 | 1.13±0.01 | 0.057±0.001 | 23.0±0 | 167±6 | 3.50±0 | 4.13±0.06 | 1.50±0 | 10±1 | 6.4±0.7 | 38±2 |
| | 700 | 10.4±0.4 | 62.0 | 838±16 | 93.4 | 13.5±0.2 | 1.0±0.2 | 0.82±0.02 | 0.063±0.001 | 26.0±0 | 180±0 | 3.73±0.06 | 4.7±0.2 | 1.83±0.06 | 8.0±0.5 | 7.2±0.7 | 39±3 |
| | 760 | 10.0±0.3 | 69.6 | 445±11 | 90.4 | 13.1±0.2 | 0.93±0.03 | 0.71±0.01 | 0.063±0.001 | 27.0±0 | 180±0 | 3.77±0.06 | 4.7±0.1 | 1.93±0.06 | 7.4±0.6 | 8±1 | 35±3 |
| DSS-2 | 0 | - | - | - | - | 31.6±0.3 | 5.22±0.07 | 3.35±0.04 | 0.05±0.02 | 11.5±0 | 36±2 | 2.27±0.06 | 2.0±0 | 0.52±0.01 | 20.7±0.6 | 6.9±0.2 | 19±1 |
| | 500 | 8.1±0.2 | 53.4 | 1293±51 | 65.6 | 30±1 | 2.35±0.05 | 2.53±0.02 | 0.12±0 | 21.7±0.6 | 66±3 | 4.5±0.2 | 3.77±0.06 | 0.98±0.02 | 38±1 | 7.4±0.3 | 44±5 |
| | 600 | 9.1±0.2 | 43.0 | 760±7 | 70.6 | 28.0±0.2 | 1.67±0.08 | 1.62±0.07 | 0.137±0.006 | 23.3±0.6 | 74.3±0.6 | 5.0±0.2 | 4.17±0.06 | 1.1±0 | 42.7±0.6 | 7.86±0.06 | 41±8 |
| | 700 | 8.7±0.3 | 46.0 | 647±100 | 73.4 | 28.1±0.5 | 1.39±0.08 | 1.26±0.03 | 0.14±0 | 24.0±0 | 76±2 | 5.0±0.1 | 4.3±0.1 | 1.2±0 | 44±1 | 8.36±0.06 | 48±3 |
| | 800 | 8.73±0.04 | 40.1 | 375±12 | 76.9 | 27.7±0.1 | 1.3±0.3 | 0.89±0.06 | 0.15±0 | 25.0±0 | 81.3±0.6 | 5.1±0.2 | 4.7±0.1 | 1.6±0 | 47±2 | 8.2±0.2 | 51±1 |
| LSS | 0 | - | - | - | - | 22.60±0.03 | 3.53±0.06 | 2.16±0.01 | 0.026±0.001 | 153±6 | 25±2 | 2.3±0.1 | 3.87±0.06 | 0.673±0.006 | 17.7±0.6 | 5.5±0.1 | 20±1 |
| | 600 | 10.7±0.1 | 56.8 | 1203±58 | 75.6 | 15.7±0.1 | 1.07±0.04 | 0.93±0.03 | 0.038±0.002 | 143±12 | 26±3 | 1.7±0.2 | 3.7±0.3 | 0.64±0.09 | 18±2 | 4.6±0.6 | 34±2 |
| | 770 | 11.98±0.04 | 53.9 | 7.3±0.3 | 88.2 | 10.5±0.1 | 1.3±0.1 | 0.50±0.03 | 0.07±0.02 | 190±26 | 34±4 | 2.4±0.4 | 5.1±0.8 | 1.1±0.2 | 24±3 | 6.3±0.8 | 38±3 |
| DWSS | 0 | - | - | - | - | 33.72±0.04 | 5.21±0.04 | 2.96±0.01 | 0.052±0.001 | 9.3±0.1 | 13.8±0.5 | 3.0±0.2 | 2.4±0.1 | 0.84±0.03 | 18.8±0.5 | 5.7±0.3 | 22±13 |
| | 600 | 9.7±0.3 | 40.0 | 502±17 | 65.4 | 31.7±0.1 | 1.35±0 | 1.56±0.03 | - | 20.0±0 | 20 | 7.1 | 5.1 | 1.9 | 45 | 3.6 | 79 |
| | 700 | 9.1±0.1 | 38.7 | 341±30 | 69.8 | 29.6±0.5 | 1.24±0.05 | 1.13±0.04 | - | 21.0±0 | 23 | 6.8 | 5.3 | 2.4 | 45 | 2.9 | 86 |
| | 800 | 8.9±0.1 | 33.0 | 323±5 | 69.9 | 31.0±0.2 | 1.3±0.2 | 0.80±0.02 | - | 22.0±0 | 35 | 6 | 5.4 | 2.7 | 46 | 3.2 | 85 |
| | 830 | 8.9±0.1 | 28.2 | 488±15 | 69.1 | 31.2±0.1 | 0.94±0.07 | 0.64±0.02 | - | 23.0±0 | 24 | 5.9 | 6.0 | 3.3 | 28 | 3.1 | 69 |
| FWR | 0 | - | - | - | - | 45.9±0.4 | 6.45±0.07 | 2.01±0.03 | 0.010±0.002 | 55±4 | 12±1 | 4.77±0.06 | 2.07±0.06 | 3.3±0.1 | 18±2 | 2.47±0.06 | 24.5±0.6 |
| | 600 | 12.0±0.3 | 35.4 | 7±2 | 70.1 | 31±1 | 1.4±0.2 | 1.05±0.04 | 0.019±0.003 | 100±43 | 7±2 | 8±4 | 4±1 | 7±3 | 25±12 | 1.9±0.8 | 42±4 |
| | 800 | 12.1±0.2 | 34.6 | 9±2 | 69.3 | 32±2 | 1.09±0.04 | 0.67±0.02 | 0.040±0.003 | 107±6 | 20±2 | 7.9±0.5 | 4.2±0.4 | 7.3±0.4 | 31±3 | 2.3±0.2 | 44±2 |
| WT | 0 | - | - | - | - | 48.1±0.1 | 6.28±0.02 | 1.11±0.01 | 0.0008±0.0001 | 3.2±0.1 | 1.1±0 | 0.80±0.02 | 0.62±0.04 | 0.42±0.01 | 0.11 | 0.66±0.02 | 5.5±0.6 |
| | 500 | 9.0±0.2 | 30.1 | 1237±85 | 22.0 | 85.0±0.6 | 1.06±0.06 | 1.37±0.03 | 0.0028±0.0001 | 9.4±0.4 | 3.6±0.2 | 2.67±0.06 | 1.87±0.06 | 1.13±0.06 | 0.43±0.01 | 1.57±0.06 | 14±2 |
| | 600 | 9.4±0.4 | 26.9 | 881±196 | 11.3 | 79.6±0.1 | 2.8±0.2 | 1.81±0.04 | 0.0033±0.0001 | 11.3±0.6 | 4.3±0.2 | 3.13±0.06 | 2.2±0.2 | 1.2±0.1 | 0.53±0.03 | 1.93±0.06 | 19±3 |

| | | | | | | | | | | | | | | | | | |
|-----|-----|------------|------|----------|------|----------|-----------|-----------|---------------|-----------|-------------|-----------|-----------|-------------|-------------|-------------|----------|
| | 700 | 11.39±0.05 | 21.0 | 964±26 | 15.5 | 85.4±0.5 | 1.61±0.04 | 1.53±0.07 | 0.0039±0.0002 | 12.3±0.06 | 5.1±0.3 | 3.43±0.06 | 2.7±0.1 | 1.4±0.2 | 0.61±0.04 | 2.27±0.06 | 21±3 |
| | 800 | 11.8±0.1 | 18.4 | 3.4±0.2 | 15.5 | 85±2 | 1.5±0.2 | 1.41±0.04 | 0.0041±0.0003 | 13.3±0.6 | 5.0±0.2 | 3.77±0.06 | 2.73±0.06 | 1.2±0.1 | 0.54±0.02 | 2.53±0.06 | 19±2 |
| GW | 0 | - | - | - | - | 45.9±0.2 | 5.93±0.01 | 0.54±0 | 0.0021±0.0003 | 6.8±0.1 | 3.8±0.3 | 2.4±0.1 | 1.07±0.06 | 0.29±0.06 | 0.56±0.01 | 0.49±0.01 | 15±1 |
| | 500 | 9.6±0.1 | 30.7 | 1135±22 | 40.2 | 55.4±0.3 | 2.18±0.02 | 0.94±0.03 | 0.012±0 | 32.0±0 | 17.3±0.6 | 5.6±0.2 | 4.8±0.2 | 1.1±0 | 3.03±0.06 | 0.89±0.01 | 51±11 |
| | 600 | 11.4±0.2 | 32.1 | 37±4 | 34.8 | 60.2±0.2 | 1.4±0.1 | 0.83±0.02 | 0.0147±0.0006 | 26.0±0 | 19.7±0.06 | 7.4±0.1 | 4.37±0.06 | 1.3±0 | 4.17±0.06 | 1±0 | 56±2 |
| | 800 | 12.1±0.1 | 23.7 | 6.7±0.2 | 33.8 | 67±1 | 1.07±0.06 | 0.81±0.02 | 0.0083±0.0004 | 28.7±0.06 | 15±0 | 7.93±0.06 | 4.13±0.06 | 1.8±0 | 2.57±0.06 | 0.78±0.03 | 49±2 |
| CWC | 0 | - | - | - | - | 50.3±0.1 | 6.17±0.05 | 0.09±0.02 | - | 1.5±0.1 | 0.023±0.002 | 0.77±0.05 | 0.17±0 | 0.009±0.001 | 0.080±0.009 | 0.073±0.003 | 8.0±0.9 |
| | 530 | 9.2±0.1 | 19.0 | 1049±36 | 3.2 | 91.4±0.2 | 2.0±0.2 | 0.56±0.02 | - | 7.0±0.6 | 0.3±0.2 | 3.5±0.2 | 0.82±0.05 | 0.044±0.002 | 0.36±0.03 | 0.081±0.004 | 14±1 |
| | 600 | 9.8±0.1 | 21.1 | 1213±83 | 3.2 | 92.5±0.3 | 1.40±0.02 | 0.60±0.02 | - | 7.9±0.5 | 0.21±0.09 | 3.9±0.2 | 0.88±0.05 | 0.051±0.006 | 0.41±0.03 | 0.083±0.001 | 17.7±0.6 |
| | 700 | 9.80±0.03 | 16.9 | 1707±139 | 3.7 | 91±3 | 1.0±0.1 | 0.68±0.02 | - | 8.0±0.2 | 0.13±0.04 | 4.03±0.06 | 0.91±0.02 | 0.052±0.001 | 0.41±0.01 | 0.089±0.004 | 17±3 |
| | 750 | 10.1±0.1 | 21.2 | 1627±163 | 3.4 | 90±3 | 0.70±0.04 | 0.77±0.02 | - | 8.7±0.5 | 0.14±0.04 | 4.27±0.06 | 0.96±0.02 | 0.057±0.002 | 0.44±0.01 | 0.11±0.01 | 19±1 |

Table S.3: Specific surface area (SSA) and pore volume (PV) for the biochars produced

| Sample | Pyr temp (°C) | N2 (>1.5 nm) | | | | CO2 (0.4-1.5 nm) | |
|--------|------------------|--------------------------------|--------------------|--------------------------------|--------------------|--------------------------------|--------------------|
| | | BET-SA | BJH-PV | DFT-SA | DFT-PV | DFT-SA | DFT-PV |
| | | m ² g ⁻¹ | cc g ⁻¹ | m ² g ⁻¹ | cc g ⁻¹ | m ² g ⁻¹ | cc g ⁻¹ |
| DSS-1 | 500 | 81 | 0.122 | 61 | 0.104 | 123 | 0.036 |
| | 600 | 133 | 0.122 | 100 | 0.152 | 132 | 0.039 |
| | 700 | 110 | 0.111 | 84 | 0.133 | 87 | 0.027 |
| | 770 | 123 | 0.124 | 94 | 0.148 | 94 | 0.030 |
| DSS-2 | 500 | 99 | 0.134 | 70 | 0.144 | 154 | 0.044 |
| | 600 | 128 | 0.130 | 95 | 0.155 | 184 | 0.053 |
| | 700 | 156 | 0.128 | 122 | 0.167 | 169 | 0.049 |
| | 800 | 219 | 0.133 | 165 | 0.199 | 202 | 0.062 |
| LSS | 600 | 66 | 0.132 | 51 | 0.129 | 70 | 0.019 |
| | 760 | 64 | 0.163 | 51 | 0.129 | 71 | 0.021 |
| DWSS | 600 | 110 | 0.126 | 88 | 0.145 | 205 | 0.055 |
| | 700 | 128 | 0.126 | 97 | 0.153 | 165 | 0.047 |
| | 800 | 196 | 0.150 | 147 | 0.201 | 233 | 0.070 |
| | 830 | 252 | 0.204 | 195 | 0.265 | 249 | 0.080 |
| FWR | 600 | 79 | 0.104 | 60 | 0.113 | 203 | 0.054 |
| | 800 | 83 | 0.102 | 64 | 0.114 | 202 | 0.059 |
| WT | 500 | 8 | 0.005 | 5 | 0.007 | 448 | 0.126 |
| | 600 | 204 | 0.025 | 159 | 0.111 | 533 | 0.145 |
| | 700 | 269 | 0.038 | 229 | 0.150 | 511 | 0.014 |
| | 785 | 131 | 0.025 | 99 | 0.077 | 588 | 0.160 |
| | 800 | 167 | 0.024 | 129 | 0.094 | 637 | 0.177 |
| GW | 500 | 214 | 0.031 | 194 | 0.121 | 348 | 0.099 |
| | 600 | 200 | 0.027 | 167 | 0.111 | 418 | 0.115 |
| | 800 | 146 | 0.042 | 117 | 0.098 | 466 | 0.133 |

| | | | | | | | |
|-----|-----|-----|-------|-----|-------|-----|-------|
| CWC | 530 | 180 | 0.020 | 130 | 0.095 | 641 | 0.174 |
| | 600 | 297 | 0.016 | 241 | 0.146 | 661 | 0.178 |
| | 700 | 323 | 0.017 | 261 | 0.160 | 683 | 0.186 |
| | 750 | 253 | 0.024 | 201 | 0.132 | 715 | 0.199 |

Table S.4: Fixation rates (FR, %) for main and trace elements in biochars from the pyrolysis of organic wastes at various temperatures.

| Feedstock | Pyr. temp. (C) | Al | Ca | Fe | K | Mg | Na | P | S | Si | As | Ba | Cd | Co | Cr | Cu | Mo | Ni | Pb | Sr | V | Zn |
|-----------|-----------------|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CWC | 530 | - | 95 | 100 | 91 | 96 | 93 | 90 | 22 | 59 | 100 | 91 | 0 | 100 | 100 | 100 | 100 | 100 | 23 | 93 | 74 | 22 |
| | 600 | - | 100 | 100 | 100 | 100 | 100 | 100 | 24 | 69 | 93 | 100 | 0 | 100 | 100 | 100 | 100 | 100 | 11 | 100 | 75 | 12 |
| | 700 | - | 100 | 100 | 100 | 100 | 100 | 100 | 26 | 70 | 69 | 100 | 0 | 100 | 100 | 100 | 100 | 100 | 13 | 100 | 70 | 3 |
| | 750 | - | 98 | 99 | 91 | 94 | 100 | 92 | 26 | 55 | 74 | 95 | 0 | 98 | 100 | 95 | 100 | 100 | 40 | 92 | 62 | 2 |
| WT | 500 | 86 | 78 | 84 | 100 | 77 | 67 | 98 | 62 | 64 | 82 | 85 | 18 | 70 | 88 | 93 | 36 | 100 | 89 | 81 | 82 | 65 |
| | 600 | 92 | 85 | 92 | 100 | 83 | 77 | 100 | 68 | 82 | 86 | 100 | 2 | 93 | 94 | 100 | 47 | 81 | 75 | 93 | 100 | 75 |
| | 700 | 96 | 83 | 98 | 100 | 92 | 75 | 100 | 75 | 80 | 76 | 100 | 2 | 86 | 100 | 89 | 43 | 83 | 33 | 95 | 86 | 12 |
| | 800 | 91 | 81 | 85 | 100 | 82 | 66 | 97 | 77 | 64 | 64 | 100 | 1 | 87 | 82 | 94 | 38 | 71 | 13 | 97 | 93 | 4 |
| GW | 500 | 100 | 100 | 100 | 85 | 100 | 100 | 100 | 66 | 100 | 100 | 100 | 6 | 100 | 95 | 100 | 73 | 93 | 100 | 100 | 100 | 100 |
| | 600 | 100 | 100 | 100 | 97 | 100 | 100 | 100 | 70 | 100 | 98 | 100 | 2 | 100 | 100 | 100 | 100 | 100 | 85 | 100 | 100 | 100 |
| | 800 | 82 | 88 | 82 | 75 | 81 | 77 | 96 | 40 | 69 | 62 | 72 | 2 | 66 | 56 | 85 | 50 | 69 | 100 | 72 | 91 | 19 |
| DSS-1 | 500 | 86 | 76 | 69 | 79 | 72 | 30 | 84 | 45 | 51 | 29 | 65 | 57 | 70 | 83 | 84 | 47 | 85 | 75 | 61 | 61 | 83 |
| | 600 | 82 | 73 | 65 | 72 | 67 | 29 | 89 | 44 | 62 | 24 | 56 | 22 | 68 | 85 | 82 | 46 | 86 | 70 | 56 | 58 | 79 |
| | 700 | 97 | 87 | 74 | 100 | 81 | 32 | 95 | 47 | 67 | 28 | 68 | 4 | 79 | 89 | 99 | 56 | 94 | 87 | 68 | 69 | 95 |
| | 770 | 97 | 91 | 74 | 73 | 81 | 38 | 100 | 41 | 61 | 32 | 80 | 2 | 80 | 95 | 100 | 56 | 100 | 90 | 72 | 71 | 95 |
| DSS-2 | 500 | 100 | 79 | 73 | 100 | 76 | 93 | 59 | 0 | 95 | 72 | 79 | 65 | 76 | 100 | 89 | 80 | 100 | 100 | 93 | 72 | 100 |
| | 600 | 100 | 79 | 76 | 100 | 78 | 99 | 56 | 0 | 82 | 72 | 80 | 7 | 71 | 86 | 75 | 76 | 96 | 78 | 97 | 76 | 80 |
| | 700 | 100 | 84 | 81 | 100 | 83 | 100 | 67 | 0 | 99 | 75 | 92 | 1 | 73 | 85 | 78 | 83 | 100 | 77 | 100 | 79 | 84 |
| | 800 | 100 | 79 | 78 | 100 | 82 | 99 | 61 | 0 | 94 | 71 | 81 | 1 | 71 | 72 | 73 | 79 | 92 | 58 | 100 | 76 | 77 |

| | | | | | | | | | | | | | | | | | | | | | | |
|------|-----|-----|----|----|-----|----|-----|----|----|----|----|-----|----|-----|-----|----|----|-----|-----|-----|----|----|
| LSS | 600 | 85 | 55 | 60 | 88 | 54 | 81 | 90 | 79 | 97 | 86 | 100 | 10 | 85 | 100 | 48 | 86 | 96 | 86 | 100 | 89 | 54 |
| | 760 | 100 | 60 | 63 | 83 | 61 | 76 | 85 | 70 | 90 | 84 | 100 | 1 | 80 | 53 | 53 | 79 | 83 | 68 | 90 | 84 | 52 |
| FWR | 600 | 75 | 73 | 24 | 100 | 71 | 100 | 97 | 23 | 69 | 66 | 73 | 11 | 100 | 100 | 24 | 77 | 100 | 100 | 100 | 44 | 51 |
| | 800 | 100 | 75 | 63 | 100 | 77 | 100 | 93 | 24 | 69 | 70 | 73 | 2 | 100 | 100 | 23 | 82 | 100 | 72 | 100 | 44 | 7 |
| DWSS | 600 | - | 88 | 57 | 93 | 85 | 89 | 95 | 25 | 57 | 66 | 92 | 2 | 86 | 77 | 88 | 70 | 78 | 82 | 92 | 93 | 89 |
| | 700 | - | 89 | 64 | 86 | 85 | 100 | 92 | 19 | 78 | 71 | 92 | 1 | 87 | 72 | 85 | 72 | 79 | 57 | 87 | 88 | 68 |
| | 800 | - | 80 | 83 | 65 | 74 | 100 | 80 | 18 | 97 | 40 | 76 | 1 | 80 | 83 | 73 | 86 | 89 | 18 | 79 | 77 | 35 |
| | 830 | - | 71 | 48 | 54 | 71 | 100 | 42 | 15 | 70 | 8 | 67 | 0 | 73 | 71 | 68 | 60 | 72 | 3 | 71 | 71 | 4 |

Table S.5 Concentrations (ppm) of main and trace elements in condensate from the pyrolysis of digested sewage sludge (DSS-1, DSS-2), limed sewage sludge (LSS), food waste reject (FWR), waste timber (WT), and garden waste (GW) at temperatures between 500 and 800 °C. Samples analysed in triplicates shown as mean ± standard deviation

| Feedstock | Pyr. Temp. (°C) | Concentration (ppm) | | | | | | | | | | | | | | |
|-----------|-----------------|---------------------|--------|---------|----------|-------|--------|---------|----------|----|---------|----|----|-----------|----|----------|
| | | Al | Ca | Fe | K | Mg | Na | P | Si | Cr | Cu | Mo | Ni | Pb | V | Zn |
| WT | 600 | 0.92±0.07 | 129±13 | <1 | 8±1 | 78±10 | 171±21 | 0.9±0.7 | 6.7±0.7 | <1 | <1 | <1 | <1 | <1 | <1 | 1.3±0.5 |
| | 700 | <1 | 88 | <1 | 8 | 61 | 168 | <1 | 3 | <1 | <1 | <1 | <1 | 2 | <1 | 49 |
| | 800 | <1 | 84 | <1 | 9 | 67 | 197 | <1 | 5 | <1 | <1 | <1 | <1 | <1 | <1 | 1 |
| GW | 500 | 1 | 159±14 | 6.1±0.5 | 10.4±0.8 | 87±7 | 177±10 | <1 | 10.5±0.4 | <1 | <1 | <1 | <1 | 1±1 | <1 | 6.3±0.5 |
| | 600 | <1 | 114±15 | 0.7±0.3 | 10±1 | 63±10 | 157±16 | 2±1 | 6.3±0.5 | <1 | <1 | <1 | <1 | <1 | <1 | 10.8±0.8 |
| | 800 | <1 | 94±7 | <1 | 10.1±0.5 | 60±5 | 163±12 | <1 | 5.9±0.1 | <1 | <1 | <1 | <1 | 0.94±0.05 | <1 | 44±1 |
| FWR | 800 | <1 | <1 | <1 | <1 | <1 | <1 | 15±3 | 30±3 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| DSS-1 | 500 | <1 | 9±8 | 1.1±0.6 | <1 | <1 | <1 | 13±1 | 264±53 | <1 | 1.0±0.7 | <1 | <1 | <1 | <1 | 3±2 |
| | 600 | <1 | <1 | <1 | <1 | <1 | <1 | 12±1 | 79±13 | <1 | 0.8±0.3 | <1 | <1 | <1 | <1 | <1 |
| | 700 | <1 | <1 | <1 | <1 | <1 | <1 | 13±1 | 83±2 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| DSS-2 | 500 | <1 | <1 | <1 | <1 | <1 | <1 | 11±1 | 54±3 | <1 | 3±3 | <1 | <1 | <1 | <1 | 2±0 |
| | 600 | <1 | <1 | <1 | <1 | <1 | <1 | 11±1 | 79±25 | <1 | 0.8±0.3 | <1 | <1 | <1 | <1 | 1.8±0.9 |
| | 700 | <1 | <1 | <1 | <1 | <1 | <1 | 12±1 | 51±3 | <1 | 1.2±0.8 | <1 | <1 | <1 | <1 | 0.7±0.3 |

| | | | | | | | | | | | | | | | | |
|-----|-----|----|----|----|----|----|----|----------|--------|----|---------|----|----|----|----|-----|
| | 800 | <1 | <1 | <1 | <1 | <1 | <1 | 11±2 | 43±1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| LSS | 600 | <1 | <1 | <1 | <1 | <1 | <1 | 12±1 | 442±39 | <1 | 1.0±0.9 | <1 | <1 | <1 | <1 | 1±0 |
| | 760 | <1 | <1 | <1 | <1 | <1 | <1 | 11.7±0.6 | 144±16 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |

Table S.6: Flue gas emission factors, EF (mg tonne⁻¹) in the pyrolysis of DSS-1, DSS-2, LSS, WT, GW and CWC at various treatment temperatures (500-800 °C), in addition to $V_{\text{flue gas}}$ (m³ kg⁻¹), as calculated through the carbon balance approach, used to derive EFs.

| Feedstock | Pyr. temp. (°C) | $V_{\text{flue gas}}$ (m ³ kg ⁻¹) | Emission factors EF (mg tonne ⁻¹) | | | | | | | | | | | |
|-----------|-----------------|--|---|-------|--------|--------|-----|-------|------|-------|-------|-------|-------|------|
| | | | As | Ba | Cd | Co | Cr | Cu | Mo | Ni | Pb | Sr | V | Zn |
| DSS-1 | 500 | 1.09 | 0.16 | 0.26 | 0.0002 | 0.0047 | 1.5 | 0.017 | 0.30 | 0.15 | 0.022 | 0.020 | 0.14 | 0.42 |
| | 600 | 9.9 | 0.92 | 0.96 | 0.0012 | 0.018 | 13 | 0.13 | 2.8 | 1.5 | 0.44 | 0.046 | 0.74 | 1.0 |
| | 700 | 8.56 | 0.92 | 0.42 | 0.0040 | 0.19 | 33 | 0.52 | 8.3 | 7.9 | 0.95 | 0.050 | 1.6 | 3.4 |
| DSS-2 | 500 | 10.8 | 2.5 | 0.43 | 0.0075 | 0.070 | 28 | 0.52 | 12 | 2.0 | 1.3 | 0.12 | 3.1 | 1.2 |
| | 600 | 24.5 | 4.7 | 0.59 | 0.15 | 0.15 | 96 | 4.8 | 19 | 6.8 | 21 | 0.12 | 7.4 | 9.1 |
| | 700 | 29.9 | 2.6 | 0.86 | 0.051 | 1.3 | 207 | 0.66 | 13 | 76 | 2.2 | 0.10 | 5.5 | 10 |
| | 800 | 26.9 | 3.5 | 0.80 | 0.043 | 0.45 | 44 | 2.0 | 21 | 8.6 | 3.4 | 0.13 | 5.1 | 13 |
| LSS | 600 | 0.506 | 0.04 | 0.020 | 0.0015 | 0.0013 | 1.3 | 0.018 | 0.18 | 0.089 | 0.060 | 0.002 | 0.051 | 0.09 |
| | 760 | 68.9 | 8.1 | 2.2 | 0.55 | 1.6 | 208 | 2.4 | 60 | 46 | 43 | 0.23 | 18 | 69 |
| FWR | 600 | 36.9 | 7.7 | 6.4 | 0.41 | 1.3 | 291 | 24 | 83 | 45 | 208 | 0.51 | 37 | 98 |
| | 800 | 44.1 | 8.9 | 68 | 0.19 | 1.9 | 251 | 15 | 80 | 143 | 184 | 38 | 17 | 110 |
| WT | 500 | 9.01 | 1.8 | 0.42 | 0.031 | 0.39 | 11 | 9.6 | 3.1 | 3.9 | 6.1 | 0.13 | 3.5 | 8.3 |
| | 600 | 28.9 | 0.44 | 1.1 | 0.053 | 0.65 | 10 | 12 | 9.0 | 42 | 19 | 0.39 | 1.7 | 13 |
| | 700 | 65.7 | 0.79 | 1.8 | 0.21 | 1.3 | 111 | 16 | 18 | 102 | 34 | 0.53 | 4.5 | 28 |
| | 800 | 79.9 | 1.1 | 2.1 | 2.2 | 1.0 | 41 | 17 | 19 | 98 | 138 | 0.59 | 3.4 | 342 |
| GW | 500 | 23.7 | 0.23 | 2.2 | 0.015 | 3.5 | 254 | 8.9 | 19 | 133 | 4.9 | 0.35 | 2.0 | 37 |
| | 800 | 57.4 | 3.3 | 2.6 | 0.13 | 1.7 | 111 | 3.6 | 64 | 35 | 129 | 0.37 | 8.8 | 85 |
| CWC | 530 | 107.9 | 0.19 | 5.0 | n.d. | 0.12 | 32 | n.d. | 5.4 | 0.011 | 0.005 | 0.13 | 0.48 | 24 |

| | | | | | | | | | | | | | | |
|--|-----|------|------|------|------|--------|------|-------|-----|-------|-------|------|-------|----|
| | 600 | 92.8 | 0.07 | 2.9 | n.d. | 1.7 | 15 | 2.3 | 1.6 | 20 | n.d. | 0.19 | 0.091 | 13 |
| | 700 | 92.2 | 0.09 | 0.12 | n.d. | 0.063 | n.d. | 0.033 | 1.7 | 0.36 | 0.018 | 0.13 | 0.24 | 26 |
| | 750 | 116 | 0.08 | 0.72 | n.d. | 0.0084 | 1.4 | 9.9 | 9.9 | 0.081 | 0.46 | 0.22 | 0.018 | 37 |

Table S.7: Flue gas emission concentrations ($\mu\text{g m}^{-3}$) in the pyrolysis of DSS-1, DSS-2, LSS, WT, GW and CWC at various treatment temperatures (500-800 °C).

| Feedstock | Pyr. Temp (°C) | As | Cd | Co | Cr | Cu | Ni | Pb | Zn | Sum |
|-----------|----------------|-------|--------|--------|------|-------|------|------|------|------|
| DSS-1 | 500 | 0.15 | 0.0002 | 0.004 | 1.4 | 0.02 | 0.14 | 0.02 | 0.39 | 2.13 |
| | 600 | 0.09 | 0.0001 | 0.002 | 1.3 | 0.01 | 0.15 | 0.04 | 0.10 | 1.75 |
| | 700 | 0.11 | 0.0005 | 0.023 | 3.8 | 0.06 | 0.92 | 0.11 | 0.39 | 5.46 |
| DSS-2 | 500 | 0.25 | 0.0007 | 0.007 | 2.8 | 0.05 | 0.19 | 0.12 | 0.12 | 3.50 |
| | 600 | 0.16 | 0.0050 | 0.005 | 3.2 | 0.16 | 0.23 | 0.71 | 0.30 | 4.77 |
| | 700 | 0.11 | 0.0021 | 0.054 | 8.4 | 0.03 | 3.1 | 0.09 | 0.41 | 12.2 |
| | 800 | 0.14 | 0.0018 | 0.019 | 1.8 | 0.08 | 0.35 | 0.14 | 0.54 | 3.07 |
| LSS | 600 | 0.08 | 0.003 | 0.003 | 2.5 | 0.04 | 0.18 | 0.12 | 0.18 | 3.13 |
| | 760 | 0.12 | 0.008 | 0.023 | 3.0 | 0.04 | 0.66 | 0.63 | 1.0 | 5.50 |
| FWR | 600 | 0.21 | 0.011 | 0.035 | 7.9 | 0.64 | 1.2 | 5.6 | 2.7 | 18.3 |
| | 800 | 0.20 | 0.004 | 0.044 | 5.7 | 0.35 | 3.2 | 4.2 | 2.5 | 16.2 |
| WT | 500 | 0.20 | 0.003 | 0.043 | 1.2 | 1.1 | 0.44 | 0.67 | 0.92 | 4.52 |
| | 600 | 0.015 | 0.002 | 0.022 | 0.4 | 0.42 | 1.4 | 0.66 | 0.45 | 3.38 |
| | 700 | 0.012 | 0.003 | 0.019 | 1.7 | 0.25 | 1.6 | 0.52 | 0.43 | 4.48 |
| | 800 | 0.014 | 0.027 | 0.013 | 0.5 | 0.21 | 1.2 | 1.7 | 4.3 | 8.02 |
| GW | 500 | 0.010 | 0.0006 | 0.15 | 11 | 0.38 | 5.6 | 0.21 | 1.6 | 18.6 |
| | 800 | 0.058 | 0.0023 | 0.03 | 1.9 | 0.06 | 0.61 | 2.3 | 1.5 | 6.43 |
| CWC | 530 | 0.002 | n.d. | 0.0013 | 0.34 | n.d. | n.d. | n.d. | 0.26 | 0.60 |
| | 600 | 0.001 | n.d. | 0.021 | 0.18 | 0.028 | 0.24 | n.d. | 0.16 | 0.63 |

| | | | | | | | | | | |
|--|-----|-------|------|--------|------|--------|-------|-------|------|------|
| | 700 | 0.001 | n.d. | 0.0007 | n.d. | 0.0004 | 0.004 | n.d. | 0.32 | 0.32 |
| | 750 | 0.001 | n.d. | 0.0001 | 0.01 | 0.094 | 0.001 | 0.004 | 0.35 | 0.46 |

Table S.8: Mass balance for main and trace elements showing the biochar (F_{BC}), pyrolysis oil (F_{PO}), flue gas (F_{FG}) and the remaining difference (F_{diff}) fractions in the pyrolysis of DSS-1, DSS-2, LSS, WT and GW at various treatment temperatures (500-800 °C).

| Feedstock | Pyr. Temp (°C) | Fraction | Ca | Fe | K | Mg | Na | P | S | Si | Cr | Cu | Mo | Ni | Pb | V | Zn |
|-----------|----------------|------------------------------|---------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|----------------|---------------|---------------|----------------|----------------|---------------|---------------|
| DSS-1 | 500 | F_{BC} | 75.40% | 69.25% | 103.88% | 71.83% | 52.88% | 70.99% | 82.92% | 77.56% | 76.04% | 84.03% | 46.94% | 84.40% | 75.24% | 60.50% | 85.96% |
| | | F_{PO} | 0.02% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.26% | 0.44% | 0.20% | 0.75% | 0.76% | 0.00% | 0.34% | 0.20% |
| | | F_{FG} | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | | F_{diff} | 24.58% | 30.75% | -3.88% | 28.17% | 47.12% | 28.99% | 17.05% | 22.18% | 23.50% | 15.77% | 52.30% | 14.84% | 24.76% | 39.16% | 13.84% |
| | 600 | FBC | 72.59% | 64.74% | 101.96% | 66.61% | 57.19% | 69.13% | 83.53% | 67.58% | 74.03% | 81.91% | 46.37% | 85.59% | 70.33% | 58.07% | 83.35% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.01% | 0.00% | 0.08% | 0.44% | 0.15% | 0.75% | 0.75% | 0.00% | 0.34% | 0.00% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.08% | 0.00% | 0.03% | 0.00% | 0.01% | 0.01% | 0.00% | 0.00% | 0.00% |
| | | F_{diff} | 27.41% | 35.26% | -1.96% | 33.39% | 42.81% | 30.86% | 16.39% | 32.34% | 25.50% | 17.94% | 52.87% | 13.66% | 29.66% | 41.58% | 16.65% |
| | 700 | FBC | 87.14% | 74.25% | 115.50% | 80.44% | 67.88% | 84.43% | 30.00% | 1.51% | 58.94% | 69.99% | 39.22% | 66.20% | 61.15% | 49.07% | 70.23% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.09% | 0.48% | 0.00% | 0.81% | 0.81% | 0.00% | 0.37% | 0.00% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.10% | 0.00% | 0.08% | 0.00% | 0.03% | 0.03% | 0.00% | 0.00% | 0.00% |
| | | F_{diff} | 12.86% | 25.75% | -15.50% | 19.56% | 32.12% | 15.55% | 69.89% | 98.40% | 40.50% | 30.01% | 59.94% | 32.95% | 38.84% | 50.56% | 29.77% |
| DSS-2 | 500 | FBC | 76.08% | 70.16% | 76.12% | 72.75% | 49.72% | 66.68% | 39.73% | 60.04% | 179.53% | 85.44% | 76.85% | 165.92% | 136.92% | 69.15% | 107.09% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.10% | 0.75% | 0.80% | 2.86% | 1.22% | 0.00% | 0.93% | 0.22% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.26% | 0.00% | 0.11% | 0.00% | 0.19% | 0.01% | 0.02% | 0.02% | 0.00% |
| | | F_{diff} | 23.92% | 29.84% | 23.88% | 27.25% | 50.28% | 33.30% | 60.01% | 39.85% | -80.39% | 13.75% | 20.10% | -67.16% | -36.93% | 29.90% | -7.32% |
| | 600 | FBC | 75.90% | 73.21% | 79.46% | 74.55% | 47.78% | 69.36% | 38.03% | 71.48% | 79.13% | 71.57% | 73.12% | 91.84% | 74.69% | 72.88% | 74.02% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.15% | 0.75% | 0.27% | 2.86% | 1.22% | 0.00% | 0.93% | 0.20% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.23% | 0.00% | 0.16% | 0.00% | 0.12% | 0.02% | 0.11% | 0.02% | 0.00% |
| | | F_{diff} | 24.10% | 26.79% | 20.54% | 25.45% | 52.22% | 30.62% | 61.74% | 28.37% | 19.97% | 28.16% | 23.89% | 6.92% | 25.20% | 26.18% | 25.78% |

| | | | | | | | | | | | | | | | | | |
|-----|-----|--------------|---------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|
| | 700 | FBC | 80.59% | 77.26% | 80.93% | 79.41% | 51.98% | 72.16% | 39.97% | 75.75% | 79.08% | 74.99% | 79.47% | 97.36% | 73.93% | 75.87% | 76.02% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.03% | 0.00% | 0.13% | 1.02% | 0.51% | 3.90% | 1.67% | 0.00% | 1.27% | 0.10% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.50% | 0.00% | 0.56% | 0.00% | 0.13% | 0.34% | 0.02% | 0.02% | 0.00% |
| | | Fdiff | 19.41% | 22.74% | 19.07% | 20.59% | 48.02% | 27.81% | 59.53% | 24.12% | 19.34% | 24.50% | 16.50% | 0.64% | 26.05% | 22.84% | 23.88% |
| | | FBC | 75.83% | 74.69% | 74.59% | 78.41% | 54.98% | 72.26% | 31.23% | 61.92% | 72.37% | 69.77% | 75.39% | 87.95% | 55.35% | 72.65% | 70.07% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.10% | 0.89% | 0.00% | 3.42% | 1.46% | 0.00% | 1.12% | 0.00% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.49% | 0.00% | 0.09% | 0.00% | 0.16% | 0.03% | 0.02% | 0.01% | 0.00% |
| | | Fdiff | 24.16% | 25.31% | 25.41% | 21.59% | 45.02% | 27.71% | 68.28% | 37.98% | 26.64% | 30.23% | 21.02% | 10.56% | 44.63% | 26.22% | 29.92% |
| | 800 | FBC | 53.14% | 57.32% | 39.40% | 52.03% | 77.43% | 86.25% | 75.42% | 92.81% | 90.36% | 46.35% | 82.27% | 92.49% | 82.76% | 85.53% | 47.97% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.01% | 0.00% | 0.51% | 0.51% | 0.11% | 2.39% | 0.83% | 0.00% | 0.62% | 0.07% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.01% | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | | Fdiff | 46.86% | 42.68% | 60.60% | 47.97% | 22.57% | 13.73% | 24.58% | 6.67% | 9.12% | 53.53% | 15.34% | 6.68% | 17.24% | 13.85% | 51.97% |
| | | FBC | 57.40% | 60.47% | 46.23% | 58.44% | 72.49% | 81.74% | 67.25% | 86.07% | 74.93% | 50.84% | 75.94% | 79.64% | 65.06% | 80.80% | 73.51% |
| | | FPO | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.01% | 0.00% | 0.17% | 0.52% | 0.00% | 2.45% | 0.85% | 0.00% | 0.63% | 0.00% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.95% | 0.01% | 0.43% | 0.00% | 0.57% | 0.15% | 0.08% | 0.04% | 0.01% |
| | | Fdiff | 42.60% | 39.52% | 53.77% | 41.56% | 27.51% | 18.25% | 31.79% | 13.76% | 24.12% | 49.15% | 21.04% | 19.35% | 34.86% | 18.53% | 26.48% |
| LSS | 600 | FBC | 82.63% | 89.03% | 192.59% | 43.21% | 74.65% | 104.83% | 65.88% | 79.83% | 96.26% | 117.92% | 45.53% | 78.65% | 72.52% | 99.69% | 72.70% |
| | | FPO | 1.84% | 0.00% | 0.74% | 5.20% | 10.11% | 0.36% | 0.03% | 0.05% | 0.61% | 0.00% | 22.65% | 4.05% | 0.00% | 9.81% | 0.12% |
| | | FFG | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.01% | 0.01% | 0.01% | 0.01% | 0.33% | 0.28% | 0.02% | 0.03% | 0.00% |
| | | Fdiff | 15.53% | 10.96% | -93.33% | 51.60% | 15.23% | -5.19% | 34.08% | 20.11% | 3.11% | -17.93% | 31.50% | 17.03% | 27.46% | -9.53% | 27.17% |
| | 760 | FBC | 80.81% | 94.78% | 140.37% | 83.79% | 72.53% | 99.16% | 72.67% | 77.93% | 92.15% | 86.10% | 41.61% | 80.60% | 31.86% | 83.58% | 13.30% |
| | | FPO | 1.12% | 0.00% | 0.64% | 3.65% | 8.91% | 0.00% | 0.00% | 0.02% | 0.55% | 0.00% | 20.28% | 3.63% | 2.48% | 8.79% | 4.07% |
| | | FFG | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.01% | 0.06% | 0.01% | 0.38% | 0.38% | 0.02% | 0.04% | 0.00% |
| | | Fdiff | 18.07% | 5.21% | -41.01% | 12.57% | 18.56% | 0.84% | 27.30% | 22.04% | 7.24% | 13.89% | 37.73% | 15.39% | 65.63% | 7.59% | 82.62% |
| | 800 | FBC | 78.62% | 82.54% | 138.60% | 75.41% | 64.46% | 94.26% | 74.73% | 62.34% | 69.40% | 91.40% | 36.82% | 69.19% | 12.45% | 90.91% | 3.19% |
| | | FPO | 1.03% | 0.00% | 0.69% | 3.84% | 10.02% | 0.00% | 0.00% | 0.03% | 0.53% | 0.00% | 19.45% | 3.48% | 0.00% | 8.43% | 0.08% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.03% | 0.01% | 0.02% | 0.01% | 0.36% | 0.33% | 0.08% | 0.03% | 0.01% |
| | | Fdiff | 20.35% | 17.46% | -39.29% | 20.75% | 25.52% | 5.74% | 25.24% | 37.62% | 30.06% | 8.59% | 43.37% | 27.00% | 87.48% | 0.64% | 96.72% |
| WT | 600 | FBC | 141.69% | 136.67% | 84.85% | 72.42% | 133.81% | 168.65% | 65.48% | 103.48% | 86.33% | 144.07% | 72.82% | 92.48% | 187.59% | 167.29% | 172.28% |
| | | FPO | | | | | | | | | | | | | | | |
| | | FFG | | | | | | | | | | | | | | | |
| | | Fdiff | | | | | | | | | | | | | | | |
| | 700 | FBC | | | | | | | | | | | | | | | |
| | | FPO | | | | | | | | | | | | | | | |
| | | FFG | | | | | | | | | | | | | | | |
| | | Fdiff | | | | | | | | | | | | | | | |
| | 800 | FBC | | | | | | | | | | | | | | | |
| | | FPO | | | | | | | | | | | | | | | |
| | | FFG | | | | | | | | | | | | | | | |
| | | Fdiff | | | | | | | | | | | | | | | |
| GW | 500 | FBC | | | | | | | | | | | | | | | |
| | | FPO | | | | | | | | | | | | | | | |
| | | FFG | | | | | | | | | | | | | | | |
| | | Fdiff | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | |
|--|-----|--------------|----------------|----------------|---------------|----------------|----------------|----------------|---------------|---------------|---------------|----------------|---------------|---------------|----------------|----------------|----------------|
| | | FPO | 0.96% | 0.07% | 0.11% | 5.17% | 4.57% | 0.00% | 0.00% | 0.03% | 0.52% | 0.00% | 7.87% | 1.65% | 10.18% | 3.25% | 2.17% |
| | | FFG | 0.00% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.02% | 0.00% | 0.26% | 0.02% | 0.29% | 0.43% | 0.04% | 0.01% | 0.01% |
| | | Fdiff | -42.66% | -36.75% | 15.04% | 22.41% | -38.39% | -68.65% | 34.49% | -3.51% | 12.89% | -44.09% | 19.01% | 5.44% | -97.82% | -70.56% | -74.46% |
| | 800 | FBC | 87.71% | 81.73% | 43.61% | 124.16% | 76.81% | 95.46% | 39.63% | 68.71% | 54.57% | 85.02% | 49.79% | 68.89% | 131.00% | 90.49% | 66.80% |
| | | FPO | 0.43% | 0.00% | 0.08% | 2.70% | 3.20% | 0.00% | 0.00% | 0.01% | 0.40% | 0.00% | 5.97% | 1.25% | 5.82% | 2.46% | 11.48% |
| | | FFG | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.53% | 0.00% | 0.08% | 0.01% | 0.66% | 0.08% | 0.70% | 0.04% | 0.02% |
| | | Fdiff | 11.85% | 18.27% | 56.31% | -26.86% | 19.99% | 4.54% | 59.84% | 31.27% | 44.96% | 14.98% | 43.58% | 29.78% | -37.52% | 7.01% | 21.70% |

1 *Table S.9: Leachable concentrations ($C_{leachable}$, mg kg^{-1}) of selected heavy metals from biochars at*
2 *different pH levels. UA = unaltered pH. Showing mean with standard deviation, and min and max*
3 *range.*

| Waste.type | Pyr.temp | pH | name | mean | sd | min | max | n |
|------------|----------|-----|------|---------|---------|---------|---------|---|
| CWC | 530 | 4 | As | 0.007 | 0.002 | 0.006 | 0.009 | 3 |
| CWC | 530 | 4 | Cd | 0.0004 | 0.0004 | 0.0001 | 0.0008 | 3 |
| CWC | 530 | 4 | Cr | 0.08 | 0.02 | 0.06 | 0.10 | 3 |
| CWC | 530 | 4 | Cu | 0.08 | 0.02 | 0.05 | 0.10 | 3 |
| CWC | 530 | 4 | Ni | 1.95 | 0.08 | 1.91 | 2.05 | 3 |
| CWC | 530 | 4 | Pb | 0.2 | 0.1 | 0.1 | 0.3 | 3 |
| CWC | 530 | 4 | Zn | 6.4 | 0.3 | 6.0 | 6.7 | 3 |
| CWC | 530 | 5.5 | As | 0.003 | 0.001 | 0.002 | 0.004 | 3 |
| CWC | 530 | 5.5 | Cd | 0.0005 | 0.0001 | 0.0004 | 0.0006 | 3 |
| CWC | 530 | 5.5 | Cr | 0.013 | 0.009 | 0.004 | 0.021 | 3 |
| CWC | 530 | 5.5 | Cu | 0.020 | 0.010 | 0.009 | 0.026 | 3 |
| CWC | 530 | 5.5 | Ni | 1.06 | 0.04 | 1.03 | 1.10 | 3 |
| CWC | 530 | 5.5 | Pb | 0.06 | 0.01 | 0.05 | 0.07 | 3 |
| CWC | 530 | 5.5 | Zn | 4.4 | 0.2 | 4.3 | 4.6 | 3 |
| CWC | 530 | 7 | As | 0.0018 | 0.0005 | 0.0014 | 0.0023 | 3 |
| CWC | 530 | 7 | Cd | 0.00005 | 0.00008 | n.d. | 0.00014 | 3 |
| CWC | 530 | 7 | Cr | 0.001 | 0.002 | n.d. | 0.003 | 3 |
| CWC | 530 | 7 | Cu | 0.006 | 0.001 | 0.004 | 0.007 | 3 |
| CWC | 530 | 7 | Ni | 0.13 | 0.01 | 0.12 | 0.14 | 3 |
| CWC | 530 | 7 | Pb | 0.04 | 0.01 | 0.03 | 0.05 | 3 |
| CWC | 530 | 7 | Zn | 0.86 | 0.07 | 0.79 | 0.94 | 3 |
| CWC | 530 | UA | As | 0.0019 | 0.0003 | 0.0016 | 0.0021 | 3 |
| CWC | 530 | UA | Cd | 0.00014 | 0.00002 | 0.00013 | 0.00016 | 3 |
| CWC | 530 | UA | Cr | 0.001 | 0.001 | n.d. | 0.003 | 3 |
| CWC | 530 | UA | Cu | 0.003 | 0.002 | 0.002 | 0.006 | 3 |
| CWC | 530 | UA | Ni | 0.0020 | 0.0009 | 0.0013 | 0.0030 | 3 |
| CWC | 530 | UA | Pb | 0.04 | 0.03 | 0.01 | 0.06 | 3 |
| CWC | 530 | UA | Zn | 0.20 | 0.07 | 0.13 | 0.28 | 3 |
| CWC | 600 | 4 | As | 0.0047 | 0.0003 | 0.0043 | 0.0049 | 3 |
| CWC | 600 | 4 | Cd | 0.0004 | 0.0002 | 0.0001 | 0.0006 | 3 |
| CWC | 600 | 4 | Cr | 0.092 | 0.003 | 0.090 | 0.095 | 3 |
| CWC | 600 | 4 | Cu | 0.056 | 0.005 | 0.052 | 0.062 | 3 |
| CWC | 600 | 4 | Ni | 1.9 | 0.2 | 1.7 | 2.1 | 3 |
| CWC | 600 | 4 | Pb | 0.09 | 0.01 | 0.08 | 0.10 | 3 |
| CWC | 600 | 4 | Zn | 3.2 | 0.3 | 3.0 | 3.5 | 3 |
| CWC | 600 | 5.5 | As | 0.004 | 0.001 | 0.003 | 0.005 | 3 |
| CWC | 600 | 5.5 | Cd | 0.00014 | 0.00001 | 0.00013 | 0.00014 | 3 |
| CWC | 600 | 5.5 | Cr | 0.050 | 0.006 | 0.043 | 0.055 | 3 |
| CWC | 600 | 5.5 | Cu | 0.041 | 0.006 | 0.036 | 0.047 | 3 |
| CWC | 600 | 5.5 | Ni | 1.38 | 0.09 | 1.29 | 1.47 | 3 |

| | | | | | | | | |
|-----|-----|-----|----|---------|---------|--------|---------|---|
| CWC | 600 | 5.5 | Pb | 0.08 | 0.04 | 0.04 | 0.12 | 3 |
| CWC | 600 | 5.5 | Zn | 2.58 | 0.06 | 2.52 | 2.64 | 3 |
| CWC | 600 | 7 | As | 0.002 | 0.001 | 0.002 | 0.003 | 3 |
| CWC | 600 | 7 | Cd | 0.0002 | 0.0002 | 0.0001 | 0.0005 | 3 |
| CWC | 600 | 7 | Cr | n.d. | - | n.d. | n.d. | 3 |
| CWC | 600 | 7 | Cu | 0.003 | 0.002 | 0.002 | 0.006 | 3 |
| CWC | 600 | 7 | Ni | 0.23 | 0.05 | 0.18 | 0.29 | 3 |
| CWC | 600 | 7 | Pb | 0.052 | 0.001 | 0.051 | 0.053 | 3 |
| CWC | 600 | 7 | Zn | 0.6 | 0.2 | 0.5 | 0.8 | 3 |
| CWC | 600 | UA | As | 0.002 | 0.001 | 0.001 | 0.003 | 3 |
| CWC | 600 | UA | Cd | 0.00005 | 0.00008 | n.d. | 0.00014 | 3 |
| CWC | 600 | UA | Cr | n.d. | - | n.d. | n.d. | 3 |
| CWC | 600 | UA | Cu | 0.005 | 0.003 | 0.002 | 0.007 | 3 |
| CWC | 600 | UA | Ni | 0.002 | 0.002 | n.d. | 0.004 | 3 |
| CWC | 600 | UA | Pb | 0.07 | 0.02 | 0.05 | 0.08 | 3 |
| CWC | 600 | UA | Zn | 0.12 | 0.04 | 0.07 | 0.15 | 3 |
| CWC | 700 | 4 | As | 0.005 | 0.001 | 0.004 | 0.006 | 3 |
| CWC | 700 | 4 | Cd | 0.0003 | 0.0001 | 0.0003 | 0.0004 | 3 |
| CWC | 700 | 4 | Cr | 0.16 | 0.01 | 0.14 | 0.17 | 3 |
| CWC | 700 | 4 | Cu | 0.021 | 0.003 | 0.018 | 0.024 | 3 |
| CWC | 700 | 4 | Ni | 1.9 | 0.1 | 1.7 | 2.0 | 3 |
| CWC | 700 | 4 | Pb | 0.08 | 0.04 | 0.04 | 0.12 | 3 |
| CWC | 700 | 4 | Zn | 1.46 | 0.08 | 1.39 | 1.54 | 3 |
| CWC | 700 | 5.5 | As | 0.004 | 0.001 | 0.004 | 0.005 | 3 |
| CWC | 700 | 5.5 | Cd | 0.0005 | 0.0003 | 0.0001 | 0.0008 | 3 |
| CWC | 700 | 5.5 | Cr | 0.10 | 0.05 | 0.05 | 0.16 | 3 |
| CWC | 700 | 5.5 | Cu | 0.020 | 0.005 | 0.017 | 0.026 | 3 |
| CWC | 700 | 5.5 | Ni | 1.5 | 0.3 | 1.2 | 1.8 | 3 |
| CWC | 700 | 5.5 | Pb | 0.07 | 0.02 | 0.04 | 0.09 | 3 |
| CWC | 700 | 5.5 | Zn | 1.3 | 0.1 | 1.2 | 1.4 | 3 |
| CWC | 700 | 7 | As | 0.0023 | 0.0003 | 0.0019 | 0.0026 | 3 |
| CWC | 700 | 7 | Cd | 0.0001 | 0.0001 | n.d. | 0.0003 | 3 |
| CWC | 700 | 7 | Cr | n.d. | - | n.d. | n.d. | 3 |
| CWC | 700 | 7 | Cu | 0.006 | 0.002 | 0.005 | 0.008 | 3 |
| CWC | 700 | 7 | Ni | 0.6 | 0.1 | 0.5 | 0.7 | 3 |
| CWC | 700 | 7 | Pb | 0.05 | 0.02 | 0.03 | 0.07 | 3 |
| CWC | 700 | 7 | Zn | 0.5 | 0.1 | 0.4 | 0.7 | 3 |
| CWC | 700 | UA | As | 0.004 | 0.001 | 0.004 | 0.006 | 3 |
| CWC | 700 | UA | Cd | 0.00005 | 0.00008 | n.d. | 0.00014 | 3 |
| CWC | 700 | UA | Cr | n.d. | - | n.d. | n.d. | 3 |
| CWC | 700 | UA | Cu | 0.008 | 0.007 | 0.002 | 0.016 | 3 |
| CWC | 700 | UA | Ni | n.d. | - | n.d. | n.d. | 3 |
| CWC | 700 | UA | Pb | 0.04 | 0.02 | 0.02 | 0.05 | 3 |
| CWC | 700 | UA | Zn | 0.08 | 0.08 | 0.02 | 0.17 | 3 |

| | | | | | | | | |
|-------|-----|-----|----|---------|---------|---------|---------|---|
| CWC | 750 | 4 | As | 0.0076 | 0.0001 | 0.0076 | 0.0077 | 3 |
| CWC | 750 | 4 | Cd | 0.0002 | 0.0002 | 0.0001 | 0.0005 | 3 |
| CWC | 750 | 4 | Cr | 0.14 | 0.02 | 0.12 | 0.16 | 3 |
| CWC | 750 | 4 | Cu | 0.016 | 0.001 | 0.014 | 0.017 | 3 |
| CWC | 750 | 4 | Ni | 2.0 | 0.2 | 1.8 | 2.2 | 3 |
| CWC | 750 | 4 | Pb | 0.06 | 0.02 | 0.03 | 0.07 | 3 |
| CWC | 750 | 4 | Zn | 1.4 | 0.1 | 1.3 | 1.5 | 3 |
| CWC | 750 | 5.5 | As | 0.0046 | 0.0006 | 0.0039 | 0.0051 | 3 |
| CWC | 750 | 5.5 | Cd | 0.0002 | 0.0002 | 0.0001 | 0.0004 | 3 |
| CWC | 750 | 5.5 | Cr | 0.034 | 0.002 | 0.032 | 0.036 | 3 |
| CWC | 750 | 5.5 | Cu | 0.011 | 0.002 | 0.009 | 0.013 | 3 |
| CWC | 750 | 5.5 | Ni | 1.3 | 0.3 | 1.1 | 1.6 | 3 |
| CWC | 750 | 5.5 | Pb | 0.049 | 0.006 | 0.044 | 0.056 | 3 |
| CWC | 750 | 5.5 | Zn | 0.94 | 0.04 | 0.90 | 0.98 | 3 |
| CWC | 750 | 7 | As | 0.0037 | 0.0007 | 0.0030 | 0.0045 | 3 |
| CWC | 750 | 7 | Cd | n.d. | - | n.d. | n.d. | 3 |
| CWC | 750 | 7 | Cr | n.d. | - | n.d. | n.d. | 3 |
| CWC | 750 | 7 | Cu | 0.001 | 0.001 | n.d. | 0.002 | 3 |
| CWC | 750 | 7 | Ni | 0.30 | 0.08 | 0.22 | 0.38 | 3 |
| CWC | 750 | 7 | Pb | 0.03 | 0.03 | 0.00 | 0.05 | 3 |
| CWC | 750 | 7 | Zn | 0.1 | 0.2 | n.d. | 0.3 | 3 |
| CWC | 750 | UA | As | 0.0031 | 0.0005 | 0.0026 | 0.0035 | 3 |
| CWC | 750 | UA | Cd | 0.0000 | 0.0001 | n.d. | 0.0001 | 3 |
| CWC | 750 | UA | Cr | n.d. | - | n.d. | n.d. | 3 |
| CWC | 750 | UA | Cu | 0.005 | 0.003 | 0.002 | 0.008 | 3 |
| CWC | 750 | UA | Ni | n.d. | - | n.d. | n.d. | 3 |
| CWC | 750 | UA | Pb | 0.03 | 0.01 | 0.02 | 0.04 | 3 |
| CWC | 750 | UA | Zn | 0.01 | 0.01 | n.d. | 0.02 | 3 |
| DSS-1 | 500 | 4 | As | 0.003 | 0.001 | 0.002 | 0.004 | 3 |
| DSS-1 | 500 | 4 | Cd | 0.060 | 0.006 | 0.054 | 0.064 | 3 |
| DSS-1 | 500 | 4 | Cr | 0.04 | 0.02 | 0.02 | 0.06 | 3 |
| DSS-1 | 500 | 4 | Cu | 0.16 | 0.08 | 0.07 | 0.23 | 3 |
| DSS-1 | 500 | 4 | Ni | 0.42 | 0.04 | 0.37 | 0.46 | 3 |
| DSS-1 | 500 | 4 | Pb | 0.046 | 0.010 | 0.035 | 0.054 | 3 |
| DSS-1 | 500 | 4 | Zn | 57 | 3 | 54 | 60 | 3 |
| DSS-1 | 500 | 5.5 | As | 0.00068 | 0.00035 | 0.00038 | 0.00106 | 3 |
| DSS-1 | 500 | 5.5 | Cd | 0.007 | 0.004 | 0.005 | 0.012 | 3 |
| DSS-1 | 500 | 5.5 | Cr | 0.004 | 0.004 | 0.001 | 0.008 | 3 |
| DSS-1 | 500 | 5.5 | Cu | 0.031 | 0.002 | 0.030 | 0.033 | 3 |
| DSS-1 | 500 | 5.5 | Ni | 0.05 | 0.03 | 0.02 | 0.07 | 3 |
| DSS-1 | 500 | 5.5 | Pb | 0.03 | 0.01 | 0.02 | 0.04 | 3 |
| DSS-1 | 500 | 5.5 | Zn | 6 | 4 | 4 | 11 | 3 |
| DSS-1 | 500 | 7 | As | 0.00048 | 0.00004 | 0.00045 | 0.00053 | 3 |
| DSS-1 | 500 | 7 | Cd | 0.00011 | 0.00005 | 0.00006 | 0.00015 | 3 |

| | | | | | | | | |
|-------|-----|-----|----|---------|---------|---------|---------|---|
| DSS-1 | 500 | 7 | Cr | 0.01 | 0.02 | 0.00 | 0.03 | 3 |
| DSS-1 | 500 | 7 | Cu | 0.028 | 0.002 | 0.025 | 0.030 | 3 |
| DSS-1 | 500 | 7 | Ni | 0.016 | 0.006 | 0.012 | 0.023 | 3 |
| DSS-1 | 500 | 7 | Pb | 0.02 | 0.01 | 0.01 | 0.04 | 3 |
| DSS-1 | 500 | 7 | Zn | 0.03 | 0.02 | 0.01 | 0.06 | 3 |
| DSS-1 | 600 | 4 | As | 0.00071 | 0.00005 | 0.00066 | 0.00075 | 3 |
| DSS-1 | 600 | 4 | Cd | 0.006 | 0.002 | 0.005 | 0.009 | 3 |
| DSS-1 | 600 | 4 | Cr | 0.003 | 0.001 | 0.002 | 0.004 | 3 |
| DSS-1 | 600 | 4 | Cu | 0.16 | 0.07 | 0.10 | 0.23 | 3 |
| DSS-1 | 600 | 4 | Ni | 0.39 | 0.03 | 0.36 | 0.42 | 3 |
| DSS-1 | 600 | 4 | Pb | 0.041 | 0.003 | 0.039 | 0.045 | 3 |
| DSS-1 | 600 | 4 | Zn | 11 | 3 | 10 | 15 | 3 |
| DSS-1 | 600 | 5.5 | As | 0.0005 | 0.0001 | 0.0004 | 0.0006 | 3 |
| DSS-1 | 600 | 5.5 | Cd | 0.00142 | 0.00021 | 0.00123 | 0.00165 | 3 |
| DSS-1 | 600 | 5.5 | Cr | 0.004 | 0.003 | 0.001 | 0.007 | 3 |
| DSS-1 | 600 | 5.5 | Cu | 0.042 | 0.008 | 0.034 | 0.050 | 3 |
| DSS-1 | 600 | 5.5 | Ni | 0.12 | 0.02 | 0.11 | 0.14 | 3 |
| DSS-1 | 600 | 5.5 | Pb | 0.04 | 0.01 | 0.03 | 0.05 | 3 |
| DSS-1 | 600 | 5.5 | Zn | 2.2 | 0.2 | 2.0 | 2.4 | 3 |
| DSS-1 | 600 | 7 | As | 0.00059 | 0.00039 | 0.00020 | 0.00098 | 3 |
| DSS-1 | 600 | 7 | Cd | 0.00008 | 0.00005 | 0.00005 | 0.00013 | 3 |
| DSS-1 | 600 | 7 | Cr | 0.00149 | 0.00082 | 0.00098 | 0.00243 | 3 |
| DSS-1 | 600 | 7 | Cu | 0.028 | 0.003 | 0.025 | 0.031 | 3 |
| DSS-1 | 600 | 7 | Ni | 0.002 | 0.002 | 0.000 | 0.004 | 3 |
| DSS-1 | 600 | 7 | Pb | 0.025 | 0.010 | 0.017 | 0.036 | 3 |
| DSS-1 | 600 | 7 | Zn | 0.026 | 0.010 | 0.015 | 0.034 | 3 |
| DSS-1 | 700 | 4 | As | 0.00154 | 0.00043 | 0.00104 | 0.00181 | 3 |
| DSS-1 | 700 | 4 | Cd | 0.00007 | 0.00002 | 0.00005 | 0.00009 | 3 |
| DSS-1 | 700 | 4 | Cr | 0.006 | 0.001 | 0.005 | 0.007 | 3 |
| DSS-1 | 700 | 4 | Cu | 0.024 | 0.002 | 0.023 | 0.026 | 3 |
| DSS-1 | 700 | 4 | Ni | 0.10 | 0.03 | 0.08 | 0.13 | 3 |
| DSS-1 | 700 | 4 | Pb | 0.03 | 0.01 | 0.02 | 0.04 | 3 |
| DSS-1 | 700 | 4 | Zn | 5.2 | 0.4 | 5.0 | 5.7 | 3 |
| DSS-1 | 700 | 5.5 | As | 0.00215 | 0.00234 | 0.00036 | 0.00480 | 3 |
| DSS-1 | 700 | 5.5 | Cd | 0.00017 | 0.00014 | 0.00002 | 0.00031 | 3 |
| DSS-1 | 700 | 5.5 | Cr | 0.00130 | 0.00065 | 0.00091 | 0.00205 | 3 |
| DSS-1 | 700 | 5.5 | Cu | 0.07 | 0.01 | 0.06 | 0.08 | 3 |
| DSS-1 | 700 | 5.5 | Ni | 0.03 | 0.02 | 0.02 | 0.05 | 3 |
| DSS-1 | 700 | 5.5 | Pb | 0.045 | 0.009 | 0.035 | 0.053 | 3 |
| DSS-1 | 700 | 5.5 | Zn | 1.4 | 0.1 | 1.4 | 1.6 | 3 |
| DSS-1 | 700 | 7 | As | 0.00163 | 0.00098 | 0.00053 | 0.00241 | 3 |
| DSS-1 | 700 | 7 | Cd | 0.00013 | 0.00009 | 0.00006 | 0.00023 | 3 |
| DSS-1 | 700 | 7 | Cr | 0.006 | 0.003 | 0.003 | 0.008 | 3 |
| DSS-1 | 700 | 7 | Cu | 0.04 | 0.02 | 0.02 | 0.06 | 3 |

| | | | | | | | | |
|-------|-----|-----|----|----------|----------|----------|----------|---|
| DSS-1 | 700 | 7 | Ni | 0.08 | 0.05 | 0.03 | 0.13 | 3 |
| DSS-1 | 700 | 7 | Pb | 0.05 | 0.02 | 0.02 | 0.06 | 3 |
| DSS-1 | 700 | 7 | Zn | 3.8 | 3.0 | 0.4 | 5.9 | 3 |
| DSS-1 | 700 | UA | As | 0.005 | 0.005 | 0.001 | 0.010 | 3 |
| DSS-1 | 700 | UA | Cd | 0.00006 | 0.00002 | 0.00004 | 0.00007 | 3 |
| DSS-1 | 700 | UA | Cr | 0.003 | 0.003 | 0.001 | 0.007 | 3 |
| DSS-1 | 700 | UA | Cu | 0.03 | 0.01 | 0.02 | 0.04 | 3 |
| DSS-1 | 700 | UA | Ni | 0.01 | 0.01 | 0.00 | 0.02 | 3 |
| DSS-1 | 700 | UA | Pb | 0.011 | 0.004 | 0.006 | 0.014 | 3 |
| DSS-1 | 700 | UA | Zn | 0.02 | 0.02 | 0.008 | 0.041 | 3 |
| DSS-1 | 770 | 4 | As | 0.002 | 0.001 | 0.001 | 0.003 | 3 |
| DSS-1 | 770 | 4 | Cd | 0.00004 | 0.00003 | 0.00001 | 0.00006 | 3 |
| DSS-1 | 770 | 4 | Cr | 0.008 | 0.003 | 0.005 | 0.010 | 3 |
| DSS-1 | 770 | 4 | Cu | 0.0219 | 0.0007 | 0.0211 | 0.0224 | 3 |
| DSS-1 | 770 | 4 | Ni | 0.06 | 0.05 | 0.03 | 0.12 | 3 |
| DSS-1 | 770 | 4 | Pb | 0.030 | 0.005 | 0.024 | 0.033 | 3 |
| DSS-1 | 770 | 4 | Zn | 5.4 | 0.1 | 5.3 | 5.5 | 3 |
| DSS-1 | 770 | 5.5 | As | 0.006 | 0.006 | 0.002 | 0.012 | 3 |
| DSS-1 | 770 | 5.5 | Cd | 0.00012 | 0.00002 | 0.00010 | 0.00014 | 3 |
| DSS-1 | 770 | 5.5 | Cr | 0.00443 | 0.00093 | 0.00350 | 0.00535 | 3 |
| DSS-1 | 770 | 5.5 | Cu | 0.08 | 0.05 | 0.04 | 0.13 | 3 |
| DSS-1 | 770 | 5.5 | Ni | 0.13 | 0.07 | 0.07 | 0.21 | 3 |
| DSS-1 | 770 | 5.5 | Pb | 0.04 | 0.02 | 0.02 | 0.06 | 3 |
| DSS-1 | 770 | 5.5 | Zn | 2.9 | 0.2 | 2.8 | 3.1 | 3 |
| DSS-1 | 770 | 7 | As | 0.000024 | 0.000001 | 0.000024 | 0.000025 | 3 |
| DSS-1 | 770 | 7 | Cd | 0.00005 | 0.00005 | 0.00001 | 0.00010 | 3 |
| DSS-1 | 770 | 7 | Cr | 0.002 | 0.002 | 0.001 | 0.004 | 3 |
| DSS-1 | 770 | 7 | Cu | 0.027 | 0.001 | 0.026 | 0.028 | 3 |
| DSS-1 | 770 | 7 | Ni | 0.003 | 0.004 | 0.000 | 0.008 | 3 |
| DSS-1 | 770 | 7 | Pb | 0.04 | 0.01 | 0.03 | 0.05 | 3 |
| DSS-1 | 770 | 7 | Zn | 0.22 | 0.04 | 0.18 | 0.24 | 3 |
| DSS-1 | 770 | UA | As | 0.00151 | 0.00026 | 0.00124 | 0.00175 | 3 |
| DSS-1 | 770 | UA | Cd | 0.00005 | 0.00005 | 0.00001 | 0.00010 | 3 |
| DSS-1 | 770 | UA | Cr | 0.00094 | 0.00004 | 0.00091 | 0.00098 | 3 |
| DSS-1 | 770 | UA | Cu | 0.03 | 0.01 | 0.02 | 0.04 | 3 |
| DSS-1 | 770 | UA | Ni | 0.0010 | 0.0008 | 0.0004 | 0.0018 | 3 |
| DSS-1 | 770 | UA | Pb | 0.013 | 0.004 | 0.009 | 0.016 | 3 |
| DSS-1 | 770 | UA | Zn | 0.0139 | 0.0005 | 0.0134 | 0.0144 | 3 |
| DSS-2 | 500 | 4 | As | 0.057 | 0.004 | 0.054 | 0.062 | 3 |
| DSS-2 | 500 | 4 | Cd | 0.061 | 0.004 | 0.057 | 0.065 | 3 |
| DSS-2 | 500 | 4 | Cr | 0.26 | 0.03 | 0.22 | 0.28 | 3 |
| DSS-2 | 500 | 4 | Cu | 2.03 | 0.07 | 1.96 | 2.11 | 3 |
| DSS-2 | 500 | 4 | Ni | 1.54 | 0.08 | 1.49 | 1.63 | 3 |
| DSS-2 | 500 | 4 | Pb | 1.0 | 0.4 | 0.6 | 1.4 | 3 |

| | | | | | | | | |
|-------|-----|-----|----|-------------|---------|-----------|-----------|---|
| DSS-2 | 500 | 4 | Zn | 66.68286833 | 2.011 | 64.363144 | 67.934783 | 3 |
| DSS-2 | 500 | 5.5 | As | 0.016 | 0.002 | 0.013 | 0.018 | 3 |
| DSS-2 | 500 | 5.5 | Cd | 0.023 | 0.002 | 0.020 | 0.024 | 3 |
| DSS-2 | 500 | 5.5 | Cr | 0.030 | 0.002 | 0.028 | 0.031 | 3 |
| DSS-2 | 500 | 5.5 | Cu | 1.92 | 0.05 | 1.86 | 1.96 | 3 |
| DSS-2 | 500 | 5.5 | Ni | 0.57 | 0.06 | 0.53 | 0.64 | 3 |
| DSS-2 | 500 | 5.5 | Pb | 0.15 | 0.06 | 0.08 | 0.18 | 3 |
| DSS-2 | 500 | 5.5 | Zn | 31 | 4 | 27 | 34 | 3 |
| DSS-2 | 500 | 7 | As | 0.0010 | 0.0001 | 0.0009 | 0.0011 | 3 |
| DSS-2 | 500 | 7 | Cd | 0.0008 | 0.0003 | 0.0006 | 0.0012 | 3 |
| DSS-2 | 500 | 7 | Cr | 0.007 | 0.000 | 0.007 | 0.008 | 3 |
| DSS-2 | 500 | 7 | Cu | 1.86 | 0.03 | 1.84 | 1.89 | 3 |
| DSS-2 | 500 | 7 | Ni | 0.04 | 0.02 | 0.02 | 0.05 | 3 |
| DSS-2 | 500 | 7 | Pb | 0.07 | 0.02 | 0.06 | 0.09 | 3 |
| DSS-2 | 500 | 7 | Zn | 2.3 | 0.6 | 1.8 | 3.0 | 3 |
| DSS-2 | 500 | UA | As | 0.002 | 0.000 | 0.002 | 0.002 | 3 |
| DSS-2 | 500 | UA | Cd | 0.00032 | 0.00002 | 0.00030 | 0.00033 | 3 |
| DSS-2 | 500 | UA | Cr | 0.008 | 0.003 | 0.006 | 0.011 | 3 |
| DSS-2 | 500 | UA | Cu | 2.2 | 0.4 | 1.9 | 2.6 | 3 |
| DSS-2 | 500 | UA | Ni | 0.00054 | 0.00001 | 0.00053 | 0.00055 | 3 |
| DSS-2 | 500 | UA | Pb | 0.068 | 0.003 | 0.066 | 0.072 | 3 |
| DSS-2 | 500 | UA | Zn | 1.6 | 0.1 | 1.5 | 1.8 | 3 |
| DSS-2 | 600 | 4 | As | 0.04 | 0.02 | 0.02 | 0.05 | 3 |
| DSS-2 | 600 | 4 | Cd | 0.004 | 0.002 | 0.002 | 0.005 | 3 |
| DSS-2 | 600 | 4 | Cr | 0.21 | 0.07 | 0.15 | 0.29 | 3 |
| DSS-2 | 600 | 4 | Cu | 0.06 | 0.01 | 0.05 | 0.07 | 3 |
| DSS-2 | 600 | 4 | Ni | 1.20 | 0.09 | 1.14 | 1.30 | 3 |
| DSS-2 | 600 | 4 | Pb | 0.2 | 0.1 | 0.1 | 0.3 | 3 |
| DSS-2 | 600 | 4 | Zn | 40 | 7 | 32 | 45 | 3 |
| DSS-2 | 600 | 5.5 | As | 0.003 | 0.002 | 0.001 | 0.004 | 3 |
| DSS-2 | 600 | 5.5 | Cd | 0.0011 | 0.0005 | 0.0006 | 0.0014 | 3 |
| DSS-2 | 600 | 5.5 | Cr | 0.003 | 0.002 | 0.001 | 0.004 | 3 |
| DSS-2 | 600 | 5.5 | Cu | 0.12 | 0.09 | 0.06 | 0.22 | 3 |
| DSS-2 | 600 | 5.5 | Ni | 0.61 | 0.06 | 0.56 | 0.69 | 3 |
| DSS-2 | 600 | 5.5 | Pb | 0.063 | 0.004 | 0.060 | 0.067 | 3 |
| DSS-2 | 600 | 5.5 | Zn | 11 | 5 | 5 | 15 | 3 |
| DSS-2 | 600 | 7 | As | 0.00018 | 0.00012 | 0.00005 | 0.00030 | 3 |
| DSS-2 | 600 | 7 | Cd | 0.00017 | 0.00003 | 0.00014 | 0.00020 | 3 |
| DSS-2 | 600 | 7 | Cr | 0.003 | 0.003 | 0.001 | 0.006 | 3 |
| DSS-2 | 600 | 7 | Cu | 0.04 | 0.01 | 0.03 | 0.06 | 3 |
| DSS-2 | 600 | 7 | Ni | 0.05 | 0.01 | 0.03 | 0.05 | 3 |
| DSS-2 | 600 | 7 | Pb | 0.024 | 0.002 | 0.022 | 0.026 | 3 |
| DSS-2 | 600 | 7 | Zn | 0.4 | 0.2 | 0.3 | 0.5 | 3 |
| DSS-2 | 600 | UA | As | 0.00039 | 0.00031 | 0.00019 | 0.00074 | 3 |

| | | | | | | | | |
|-------|-----|-----|----|---------|---------|---------|---------|---|
| DSS-2 | 600 | UA | Cd | 0.00033 | 0.00004 | 0.00029 | 0.00037 | 3 |
| DSS-2 | 600 | UA | Cr | 0.006 | 0.003 | 0.002 | 0.009 | 3 |
| DSS-2 | 600 | UA | Cu | 0.03 | 0.01 | 0.02 | 0.05 | 3 |
| DSS-2 | 600 | UA | Ni | 0.00063 | 0.00019 | 0.00050 | 0.00085 | 3 |
| DSS-2 | 600 | UA | Pb | 0.022 | 0.009 | 0.016 | 0.032 | 3 |
| DSS-2 | 600 | UA | Zn | 0.07 | 0.03 | 0.04 | 0.11 | 3 |
| DSS-2 | 700 | 4 | As | 0.0069 | 0.0005 | 0.0066 | 0.0074 | 3 |
| DSS-2 | 700 | 4 | Cd | 0.00041 | 0.00010 | 0.00029 | 0.00048 | 3 |
| DSS-2 | 700 | 4 | Cr | 0.114 | 0.009 | 0.108 | 0.124 | 3 |
| DSS-2 | 700 | 4 | Cu | 0.06 | 0.02 | 0.05 | 0.07 | 3 |
| DSS-2 | 700 | 4 | Ni | 1.3 | 0.1 | 1.1 | 1.4 | 3 |
| DSS-2 | 700 | 4 | Pb | 0.056 | 0.008 | 0.051 | 0.066 | 3 |
| DSS-2 | 700 | 4 | Zn | 13 | 11 | n.d. | 19 | 3 |
| DSS-2 | 700 | 5.5 | As | 0.00324 | 0.00079 | 0.00233 | 0.00379 | 3 |
| DSS-2 | 700 | 5.5 | Cd | 0.00035 | 0.00008 | 0.00027 | 0.00043 | 3 |
| DSS-2 | 700 | 5.5 | Cr | 0.019 | 0.005 | 0.014 | 0.025 | 3 |
| DSS-2 | 700 | 5.5 | Cu | 0.136 | 0.004 | 0.133 | 0.141 | 3 |
| DSS-2 | 700 | 5.5 | Ni | 0.6 | 0.1 | 0.5 | 0.7 | 3 |
| DSS-2 | 700 | 5.5 | Pb | 0.093 | 0.005 | 0.089 | 0.098 | 3 |
| DSS-2 | 700 | 5.5 | Zn | 8.0 | 1.0 | 7.4 | 9.2 | 3 |
| DSS-2 | 700 | 7 | As | 0.00063 | 0.00011 | 0.00056 | 0.00076 | 3 |
| DSS-2 | 700 | 7 | Cd | 0.00014 | 0.00008 | 0.00005 | 0.00018 | 3 |
| DSS-2 | 700 | 7 | Cr | 0.002 | 0.001 | 0.001 | 0.004 | 3 |
| DSS-2 | 700 | 7 | Cu | 0.022 | 0.009 | 0.016 | 0.033 | 3 |
| DSS-2 | 700 | 7 | Ni | 0.007 | 0.008 | 0.001 | 0.016 | 3 |
| DSS-2 | 700 | 7 | Pb | 0.017 | 0.003 | 0.015 | 0.020 | 3 |
| DSS-2 | 700 | 7 | Zn | 0.05 | 0.04 | 0.02 | 0.10 | 3 |
| DSS-2 | 700 | UA | As | 0.00004 | 0.00001 | 0.00003 | 0.00005 | 3 |
| DSS-2 | 700 | UA | Cd | 0.00014 | 0.00003 | 0.00011 | 0.00018 | 3 |
| DSS-2 | 700 | UA | Cr | 0.003 | 0.002 | 0.001 | 0.005 | 3 |
| DSS-2 | 700 | UA | Cu | 0.017 | 0.001 | 0.016 | 0.018 | 3 |
| DSS-2 | 700 | UA | Ni | 0.004 | 0.006 | 0.000 | 0.011 | 3 |
| DSS-2 | 700 | UA | Pb | 0.014 | 0.003 | 0.011 | 0.016 | 3 |
| DSS-2 | 700 | UA | Zn | 0.051 | 0.008 | 0.046 | 0.060 | 3 |
| DSS-2 | 800 | 4 | As | 0.00050 | 0.00013 | 0.00036 | 0.00059 | 3 |
| DSS-2 | 800 | 4 | Cd | 0.00014 | 0.00018 | 0.00001 | 0.00035 | 3 |
| DSS-2 | 800 | 4 | Cr | 0.20 | 0.01 | 0.19 | 0.21 | 3 |
| DSS-2 | 800 | 4 | Cu | 0.08 | 0.02 | 0.07 | 0.11 | 3 |
| DSS-2 | 800 | 4 | Ni | 0.44 | 0.03 | 0.43 | 0.47 | 3 |
| DSS-2 | 800 | 4 | Pb | 0.038 | 0.007 | 0.032 | 0.046 | 3 |
| DSS-2 | 800 | 4 | Zn | 9.4 | 0.3 | 9.2 | 9.7 | 3 |
| DSS-2 | 800 | 5.5 | As | 0.00284 | 0.00039 | 0.00251 | 0.00328 | 3 |
| DSS-2 | 800 | 5.5 | Cd | 0.00012 | 0.00005 | 0.00007 | 0.00017 | 3 |
| DSS-2 | 800 | 5.5 | Cr | 0.002 | 0.001 | 0.001 | 0.003 | 3 |

| | | | | | | | | |
|-------|-----|-----|----|----------|----------|----------|----------|---|
| DSS-2 | 800 | 5.5 | Cu | 0.04 | 0.01 | 0.03 | 0.06 | 3 |
| DSS-2 | 800 | 5.5 | Ni | 0.07 | 0.02 | 0.06 | 0.10 | 3 |
| DSS-2 | 800 | 5.5 | Pb | 0.03 | 0.02 | 0.02 | 0.06 | 3 |
| DSS-2 | 800 | 5.5 | Zn | 1.97 | 0.04 | 1.93 | 2.00 | 3 |
| DSS-2 | 800 | 7 | As | 0.000030 | 0.000001 | 0.000029 | 0.000030 | 3 |
| DSS-2 | 800 | 7 | Cd | 0.000066 | 0.000033 | 0.000032 | 0.000098 | 3 |
| DSS-2 | 800 | 7 | Cr | 0.008 | 0.009 | 0.001 | 0.018 | 3 |
| DSS-2 | 800 | 7 | Cu | 0.028 | 0.009 | 0.023 | 0.039 | 3 |
| DSS-2 | 800 | 7 | Ni | 0.02 | 0.01 | 0.01 | 0.03 | 3 |
| DSS-2 | 800 | 7 | Pb | 0.02 | 0.01 | 0.01 | 0.04 | 3 |
| DSS-2 | 800 | 7 | Zn | 0.071 | 0.006 | 0.068 | 0.078 | 3 |
| DSS-2 | 800 | UA | As | 0.0011 | 0.0003 | 0.0007 | 0.0014 | 3 |
| DSS-2 | 800 | UA | Cd | 0.0002 | 0.0002 | 0.0000 | 0.0004 | 3 |
| DSS-2 | 800 | UA | Cr | 0.0009 | 0.0002 | 0.0008 | 0.0011 | 3 |
| DSS-2 | 800 | UA | Cu | 0.023 | 0.001 | 0.021 | 0.024 | 3 |
| DSS-2 | 800 | UA | Ni | 0.002 | 0.002 | 0.000 | 0.005 | 3 |
| DSS-2 | 800 | UA | Pb | 0.013 | 0.002 | 0.011 | 0.015 | 3 |
| DSS-2 | 800 | UA | Zn | 0.06 | 0.01 | 0.05 | 0.07 | 3 |
| WT | 500 | 4 | As | 3.4 | 0.1 | 3.3 | 3.6 | 3 |
| WT | 500 | 4 | Cd | 0.069 | 0.008 | 0.060 | 0.074 | 3 |
| WT | 500 | 4 | Cr | 0.17 | 0.01 | 0.16 | 0.18 | 3 |
| WT | 500 | 4 | Cu | 0.64 | 0.02 | 0.62 | 0.67 | 3 |
| WT | 500 | 4 | Ni | 0.30 | 0.02 | 0.29 | 0.32 | 3 |
| WT | 500 | 4 | Pb | 7.0 | 0.8 | 6.0 | 7.5 | 3 |
| WT | 500 | 4 | Zn | 264 | 7 | 257 | 269 | 3 |
| WT | 500 | 5.5 | As | 3.0 | 0.1 | 2.9 | 3.1 | 3 |
| WT | 500 | 5.5 | Cd | 0.054 | 0.007 | 0.046 | 0.058 | 3 |
| WT | 500 | 5.5 | Cr | 0.10 | 0.02 | 0.09 | 0.12 | 3 |
| WT | 500 | 5.5 | Cu | 0.385 | 0.004 | 0.382 | 0.390 | 3 |
| WT | 500 | 5.5 | Ni | 0.4 | 0.1 | 0.2 | 0.4 | 3 |
| WT | 500 | 5.5 | Pb | 3.7 | 0.4 | 3.3 | 4.1 | 3 |
| WT | 500 | 5.5 | Zn | 219 | 9 | 211 | 229 | 3 |
| WT | 500 | 7 | As | 1.36 | 0.09 | 1.31 | 1.46 | 3 |
| WT | 500 | 7 | Cd | 0.0043 | 0.0006 | 0.0036 | 0.0049 | 3 |
| WT | 500 | 7 | Cr | n.d. | - | n.d. | n.d. | 3 |
| WT | 500 | 7 | Cu | 0.008 | 0.004 | 0.006 | 0.013 | 3 |
| WT | 500 | 7 | Ni | 0.021 | 0.006 | 0.015 | 0.027 | 3 |
| WT | 500 | 7 | Pb | 0.018 | 0.007 | 0.011 | 0.025 | 3 |
| WT | 500 | 7 | Zn | 17 | 7 | 10 | 24 | 3 |
| WT | 500 | UA | As | 1.1 | 0.1 | 1.1 | 1.3 | 3 |
| WT | 500 | UA | Cd | 0.0003 | 0.0002 | 0.0001 | 0.0004 | 3 |
| WT | 500 | UA | Cr | 0.008 | 0.002 | 0.006 | 0.009 | 3 |
| WT | 500 | UA | Cu | 0.0045 | 0.0003 | 0.0042 | 0.0047 | 3 |
| WT | 500 | UA | Ni | 0.0004 | 0.0007 | n.d. | 0.0012 | 3 |

| | | | | | | | | |
|----|-----|-----|----|---------|---------|---------|---------|---|
| WT | 500 | UA | Pb | 0.019 | 0.008 | 0.012 | 0.028 | 3 |
| WT | 500 | UA | Zn | 0.23 | 0.05 | 0.17 | 0.27 | 3 |
| WT | 600 | 4 | As | 4.5 | 0.2 | 4.2 | 4.6 | 3 |
| WT | 600 | 4 | Cd | 0.0 | 0.0 | 0.0 | 0.0 | 3 |
| WT | 600 | 4 | Cr | 0.70 | 0.07 | 0.63 | 0.75 | 3 |
| WT | 600 | 4 | Cu | 0.29 | 0.02 | 0.27 | 0.32 | 3 |
| WT | 600 | 4 | Ni | 3.1 | 0.1 | 3.0 | 3.2 | 3 |
| WT | 600 | 4 | Pb | 13 | 1 | 11 | 14 | 3 |
| WT | 600 | 4 | Zn | 433 | 37 | 409 | 475 | 3 |
| WT | 600 | 5.5 | As | 0.08 | 0.06 | 0.03 | 0.14 | 3 |
| WT | 600 | 5.5 | Cd | 0.004 | 0.001 | 0.003 | 0.005 | 3 |
| WT | 600 | 5.5 | Cr | 0.003 | 0.006 | n.d. | 0.010 | 3 |
| WT | 600 | 5.5 | Cu | 0.06 | 0.02 | 0.03 | 0.08 | 3 |
| WT | 600 | 5.5 | Ni | 1.73 | 0.04 | 1.69 | 1.77 | 3 |
| WT | 600 | 5.5 | Pb | 0.3 | 0.2 | 0.1 | 0.5 | 3 |
| WT | 600 | 5.5 | Zn | 214 | 10 | 204 | 224 | 3 |
| WT | 600 | 7 | As | 0.27 | 0.03 | 0.24 | 0.31 | 3 |
| WT | 600 | 7 | Cd | 0.00048 | 0.00008 | 0.00043 | 0.00057 | 3 |
| WT | 600 | 7 | Cr | n.d. | - | n.d. | n.d. | 3 |
| WT | 600 | 7 | Cu | 0.009 | 0.007 | 0.005 | 0.016 | 3 |
| WT | 600 | 7 | Ni | 0.22 | 0.02 | 0.21 | 0.24 | 3 |
| WT | 600 | 7 | Pb | 0.04 | 0.03 | 0.02 | 0.08 | 3 |
| WT | 600 | 7 | Zn | 29 | 11 | 18 | 40 | 3 |
| WT | 600 | UA | As | 0.53 | 0.02 | 0.51 | 0.55 | 3 |
| WT | 600 | UA | Cd | 0.00004 | 0.00007 | n.d. | 0.00012 | 3 |
| WT | 600 | UA | Cr | n.d. | - | n.d. | n.d. | 3 |
| WT | 600 | UA | Cu | 0.004 | 0.003 | 0.002 | 0.007 | 3 |
| WT | 600 | UA | Ni | n.d. | - | n.d. | n.d. | 3 |
| WT | 600 | UA | Pb | 0.045 | 0.007 | 0.037 | 0.050 | 3 |
| WT | 600 | UA | Zn | 0.02 | 0.01 | 0.01 | 0.04 | 3 |
| WT | 700 | 4 | As | 5.6 | 0.2 | 5.4 | 5.8 | 3 |
| WT | 700 | 4 | Cd | 0.0108 | 0.0009 | 0.0100 | 0.0118 | 3 |
| WT | 700 | 4 | Cr | 1.02 | 0.03 | 1.00 | 1.05 | 3 |
| WT | 700 | 4 | Cu | 0.24 | 0.02 | 0.23 | 0.27 | 3 |
| WT | 700 | 4 | Ni | 3.9 | 0.3 | 3.7 | 4.3 | 3 |
| WT | 700 | 4 | Pb | 4.2 | 0.2 | 3.9 | 4.4 | 3 |
| WT | 700 | 4 | Zn | 67 | 6 | 60 | 73 | 3 |
| WT | 700 | 5.5 | As | 2.6 | 0.2 | 2.3 | 2.8 | 3 |
| WT | 700 | 5.5 | Cd | 0.0067 | 0.0002 | 0.0064 | 0.0068 | 3 |
| WT | 700 | 5.5 | Cr | 0.46 | 0.05 | 0.41 | 0.51 | 3 |
| WT | 700 | 5.5 | Cu | 0.21 | 0.04 | 0.17 | 0.24 | 3 |
| WT | 700 | 5.5 | Ni | 3.0 | 0.1 | 2.9 | 3.1 | 3 |
| WT | 700 | 5.5 | Pb | 1.7 | 0.4 | 1.4 | 2.1 | 3 |
| WT | 700 | 5.5 | Zn | 52 | 5 | 47 | 57 | 3 |

| | | | | | | | | |
|----|-----|-----|----|---------|---------|--------|---------|---|
| WT | 700 | 7 | As | 0.24 | 0.01 | 0.22 | 0.25 | 3 |
| WT | 700 | 7 | Cd | 0.0010 | 0.0002 | 0.0009 | 0.0012 | 3 |
| WT | 700 | 7 | Cr | 0.00003 | 0.00006 | n.d. | 0.00010 | 3 |
| WT | 700 | 7 | Cu | 0.012 | 0.003 | 0.009 | 0.015 | 3 |
| WT | 700 | 7 | Ni | 0.83 | 0.03 | 0.79 | 0.85 | 3 |
| WT | 700 | 7 | Pb | 0.027 | 0.003 | 0.024 | 0.030 | 3 |
| WT | 700 | 7 | Zn | 22 | 18 | 10 | 43 | 3 |
| WT | 700 | UA | As | 0.11 | 0.05 | 0.08 | 0.17 | 3 |
| WT | 700 | UA | Cd | 0.00004 | 0.00007 | n.d. | 0.00012 | 3 |
| WT | 700 | UA | Cr | 0.001 | 0.001 | n.d. | 0.002 | 3 |
| WT | 700 | UA | Cu | 0.0018 | 0.0001 | 0.0017 | 0.0018 | 3 |
| WT | 700 | UA | Ni | 0.0002 | 0.0004 | n.d. | 0.0007 | 3 |
| WT | 700 | UA | Pb | 0.024 | 0.001 | 0.022 | 0.025 | 3 |
| WT | 700 | UA | Zn | 0.01 | 0.01 | n.d. | 0.02 | 3 |
| WT | 800 | 4 | As | 5.7 | 0.7 | 5.2 | 6.5 | 3 |
| WT | 800 | 4 | Cd | 0.0053 | 0.0002 | 0.0051 | 0.0054 | 3 |
| WT | 800 | 4 | Cr | 1.4 | 0.2 | 1.3 | 1.6 | 3 |
| WT | 800 | 4 | Cu | 0.2 | 0.1 | 0.0 | 0.3 | 3 |
| WT | 800 | 4 | Ni | 3.52 | 0.06 | 3.46 | 3.58 | 3 |
| WT | 800 | 4 | Pb | 5 | 7 | 1 | 13 | 3 |
| WT | 800 | 4 | Zn | 24 | 3 | 22 | 27 | 3 |
| WT | 800 | 5.5 | As | 0.8 | 0.1 | 0.7 | 0.9 | 3 |
| WT | 800 | 5.5 | Cd | 0.0020 | 0.0006 | 0.0016 | 0.0027 | 3 |
| WT | 800 | 5.5 | Cr | 0.057 | 0.008 | 0.049 | 0.065 | 3 |
| WT | 800 | 5.5 | Cu | 0.11 | 0.01 | 0.09 | 0.12 | 3 |
| WT | 800 | 5.5 | Ni | 2.48 | 0.07 | 2.42 | 2.55 | 3 |
| WT | 800 | 5.5 | Pb | 0.08 | 0.01 | 0.07 | 0.09 | 3 |
| WT | 800 | 5.5 | Zn | 14.2 | 0.3 | 13.9 | 14.6 | 3 |
| WT | 800 | 7 | As | 0.36 | 0.07 | 0.30 | 0.43 | 3 |
| WT | 800 | 7 | Cd | 0.0007 | 0.0003 | 0.0003 | 0.0009 | 3 |
| WT | 800 | 7 | Cr | 0.001 | 0.002 | n.d. | 0.003 | 3 |
| WT | 800 | 7 | Cu | 0.025 | 0.007 | 0.020 | 0.033 | 3 |
| WT | 800 | 7 | Ni | 1.5 | 0.1 | 1.4 | 1.6 | 3 |
| WT | 800 | 7 | Pb | 0.03 | 0.01 | 0.02 | 0.04 | 3 |
| WT | 800 | 7 | Zn | 8 | 1 | 6 | 9 | 3 |
| WT | 800 | UA | As | 0.011 | 0.009 | 0.003 | 0.021 | 3 |
| WT | 800 | UA | Cd | n.d. | - | n.d. | n.d. | 3 |
| WT | 800 | UA | Cr | 0.003 | 0.002 | n.d. | 0.005 | 3 |
| WT | 800 | UA | Cu | 0.0018 | 0.0001 | 0.0017 | 0.0018 | 3 |
| WT | 800 | UA | Ni | n.d. | - | n.d. | n.d. | 3 |
| WT | 800 | UA | Pb | 0.03 | 0.01 | 0.01 | 0.03 | 3 |
| WT | 800 | UA | Zn | 0.010 | 0.010 | n.d. | 0.019 | 3 |

4

5

6 *Table S.10: Leachable fractions ($F_{leachable}$, %) of selected heavy metals from biochars at different pH*
7 *levels. UA = unaltered pH*

| Feedstock | Pyr.temp (°C) | pH | As | Cd | Cr | Cu | Ni | Pb | Zn |
|-----------|---------------|-----|-------|--------|---------|-------|--------|--------|-------|
| CWC | 530 | UA | 9.2 | 22.73 | 0.03 | 0.05 | 0.05 | 24.25 | 0.77 |
| CWC | 530 | 7 | 8.6 | 7.51 | 0.03 | 0.08 | 3.55 | 26.88 | 3.36 |
| CWC | 530 | 5.5 | 15.9 | 80.75 | 0.29 | 0.28 | 29.10 | 37.12 | 17.31 |
| CWC | 530 | 4 | 33.8 | 67.72 | 1.82 | 1.07 | 53.74 | 121.17 | 24.84 |
| CWC | 600 | UA | 17.6 | 7.08 | n.d. | 0.10 | 0.07 | 103.44 | 0.96 |
| CWC | 600 | 7 | 15.1 | 36.83 | n.d. | 0.07 | 8.64 | 81.39 | 5.02 |
| CWC | 600 | 5.5 | 26.4 | 20.67 | 1.62 | 0.84 | 52.40 | 123.11 | 20.38 |
| CWC | 600 | 4 | 33.1 | 59.20 | 2.96 | 1.15 | 72.61 | 143.84 | 25.23 |
| CWC | 700 | UA | 40.5 | 10.34 | n.d. | 0.16 | 0.00 | 48.16 | 2.56 |
| CWC | 700 | 7 | 21.2 | 32.43 | n.d. | 0.12 | 34.32 | 59.63 | 16.54 |
| CWC | 700 | 5.5 | 38.1 | 102.72 | 6.17 | 0.39 | 85.57 | 82.77 | 39.30 |
| CWC | 700 | 4 | 47.6 | 75.18 | 9.31 | 0.40 | 105.45 | 95.76 | 45.64 |
| CWC | 750 | UA | 21.1 | 4.34 | n.d. | 0.10 | 0.00 | 10.51 | 0.26 |
| CWC | 750 | 7 | 25.0 | 0.00 | n.d. | 0.03 | 15.80 | 8.50 | 3.66 |
| CWC | 750 | 5.5 | 31.2 | 21.43 | 2.07 | 0.21 | 68.71 | 16.13 | 33.62 |
| CWC | 750 | 4 | 52.1 | 21.59 | 8.33 | 0.31 | 103.45 | 18.98 | 51.42 |
| WT | 500 | UA | 2.07 | 0.03 | 0.007 | 0.004 | 0.00 | 0.02 | 0.02 |
| WT | 500 | 7 | 2.48 | 0.38 | n.d. | 0.01 | 0.19 | 0.02 | 1.41 |
| WT | 500 | 5.5 | 5.38 | 4.79 | 0.10 | 0.35 | 3.24 | 3.28 | 18.29 |
| WT | 500 | 4 | 6.25 | 6.11 | 0.16 | 0.58 | 2.75 | 6.15 | 22.00 |
| WT | 600 | UA | 0.83 | 0.08 | n.d. | 0.002 | 0.00 | 0.05 | 0.00 |
| WT | 600 | 7 | 0.42 | 1.00 | n.d. | 0.01 | 1.08 | 0.04 | 1.92 |
| WT | 600 | 5.5 | 0.13 | 9.17 | 0.002 | 0.04 | 8.49 | 0.28 | 13.99 |
| WT | 600 | 4 | 6.93 | 28.14 | 0.45 | 0.18 | 15.09 | 13.97 | 28.22 |
| WT | 700 | UA | 0.18 | 0.06 | 0.0004 | 0.001 | 0.00 | 0.05 | 0.00 |
| WT | 700 | 7 | 0.37 | 1.52 | 0.00002 | 0.01 | 3.84 | 0.06 | 8.19 |
| WT | 700 | 5.5 | 4.06 | 9.73 | 0.28 | 0.16 | 13.82 | 3.74 | 19.88 |
| WT | 700 | 4 | 8.90 | 15.70 | 0.62 | 0.19 | 18.10 | 9.24 | 25.40 |
| WT | 800 | UA | 0.02 | 0.00 | 0.002 | 0.001 | 0.00 | 0.11 | 0.01 |
| WT | 800 | 7 | 0.61 | 3.15 | 0.001 | 0.02 | 6.97 | 0.12 | 6.96 |
| WT | 800 | 5.5 | 1.29 | 8.77 | 0.04 | 0.07 | 11.61 | 0.34 | 13.19 |
| WT | 800 | 4 | 9.55 | 23.26 | 1.03 | 0.12 | 16.50 | 19.91 | 21.90 |
| DSS-1 | 500 | UA | 0.015 | 0.01 | 0.009 | 0.02 | 0.05 | 0.10 | 0.00 |
| DSS-1 | 500 | 5.5 | 0.021 | 0.96 | 0.003 | 0.02 | 0.15 | 0.14 | 0.92 |
| DSS-1 | 500 | 4 | 0.091 | 8.10 | 0.03 | 0.10 | 1.38 | 0.21 | 8.26 |
| DSS-1 | 600 | UA | 0.021 | 0.04 | 0.003 | 0.01 | 0.01 | 0.12 | 0.00 |
| DSS-1 | 600 | 5.5 | 0.018 | 0.72 | 0.007 | 0.02 | 0.39 | 0.20 | 0.31 |
| DSS-1 | 600 | 4 | 0.025 | 3.30 | 0.007 | 0.06 | 1.24 | 0.20 | 1.62 |
| DSS-1 | 700 | UA | 0.15 | 0.22 | 0.006 | 0.01 | 0.02 | 0.04 | 0.00 |
| DSS-1 | 700 | 7 | 0.052 | 0.44 | 0.011 | 0.01 | 0.23 | 0.18 | 0.48 |

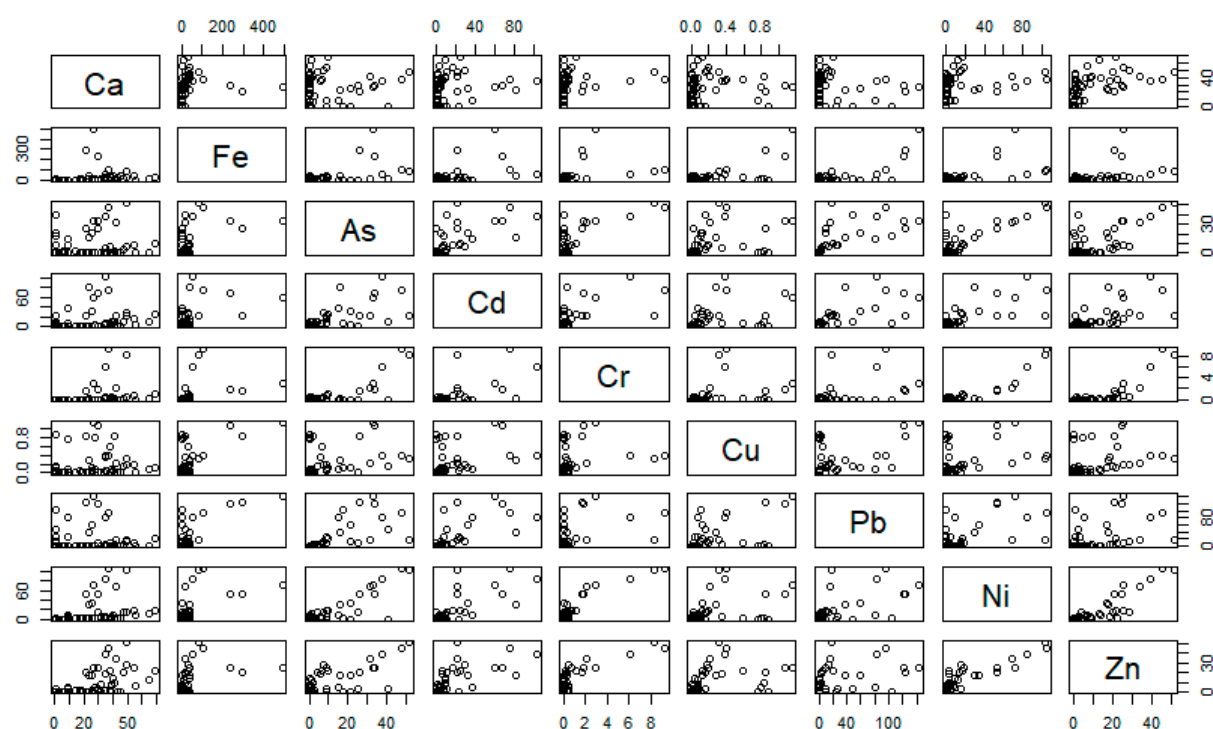
| | | | | | | | | | |
|-------|-----|-----|--------|------|-------|------|------|------|------|
| DSS-1 | 700 | 5.5 | 0.069 | 0.58 | 0.002 | 0.03 | 0.09 | 0.18 | 0.18 |
| DSS-1 | 700 | 4 | 0.049 | 0.25 | 0.011 | 0.01 | 0.29 | 0.12 | 0.65 |
| DSS-1 | 770 | UA | 0.043 | 0.17 | 0.002 | 0.01 | 0.00 | 0.05 | 0.00 |
| DSS-1 | 770 | 7 | 0.0007 | 0.21 | 0.003 | 0.01 | 0.01 | 0.16 | 0.03 |
| DSS-1 | 770 | 5.5 | 0.16 | 0.47 | 0.007 | 0.03 | 0.33 | 0.16 | 0.36 |
| DSS-1 | 770 | 4 | 0.047 | 0.17 | 0.013 | 0.01 | 0.15 | 0.12 | 0.67 |
| DSS-2 | 500 | UA | 0.048 | 0.04 | 0.008 | 0.88 | 0.00 | 0.27 | 0.22 |
| DSS-2 | 500 | 7 | 0.026 | 0.11 | 0.007 | 0.77 | 0.06 | 0.27 | 0.31 |
| DSS-2 | 500 | 5.5 | 0.43 | 3.03 | 0.03 | 0.79 | 0.90 | 0.57 | 4.29 |
| DSS-2 | 500 | 4 | 1.51 | 8.15 | 0.23 | 0.84 | 2.40 | 3.90 | 9.22 |
| DSS-2 | 600 | UA | 0.009 | 0.38 | 0.012 | 0.01 | 0.00 | 0.14 | 0.01 |
| DSS-2 | 600 | 7 | 0.004 | 0.20 | 0.005 | 0.02 | 0.14 | 0.15 | 0.07 |
| DSS-2 | 600 | 5.5 | 0.061 | 1.25 | 0.005 | 0.05 | 1.80 | 0.40 | 1.77 |
| DSS-2 | 600 | 4 | 0.84 | 4.36 | 0.40 | 0.03 | 3.54 | 1.03 | 6.44 |
| DSS-2 | 700 | UA | 0.001 | 0.59 | 0.006 | 0.01 | 0.01 | 0.09 | 0.01 |
| DSS-2 | 700 | 7 | 0.015 | 0.57 | 0.004 | 0.01 | 0.02 | 0.11 | 0.01 |
| DSS-2 | 700 | 5.5 | 0.08 | 1.46 | 0.04 | 0.06 | 1.80 | 0.58 | 1.28 |
| DSS-2 | 700 | 4 | 0.17 | 1.71 | 0.22 | 0.02 | 3.72 | 0.35 | 2.01 |
| DSS-2 | 800 | UA | 0.025 | 2.67 | 0.002 | 0.01 | 0.01 | 0.10 | 0.01 |
| DSS-2 | 800 | 7 | 0.0007 | 0.78 | 0.02 | 0.01 | 0.05 | 0.19 | 0.01 |
| DSS-2 | 800 | 5.5 | 0.07 | 1.38 | 0.003 | 0.02 | 0.21 | 0.25 | 0.31 |
| DSS-2 | 800 | 4 | 0.011 | 1.63 | 0.40 | 0.04 | 1.30 | 0.30 | 1.47 |

Table S.11: Linear regression analyses of how leachable concentrations of heavy metals (As, Ba, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sr, V and Zn) correlate to pyrolysis temperature (500-800 °C) at different target pH levels (UA=unaltered pH of biochar, 7, 5.5 and 4)

| Feedstock | pH | As | Ba | Cd | Co | Cr | Cu | Mo | Ni | Pb | Sr | V | Zn |
|-----------|-----|-------------------------------|-------------------------------|-------------------------------|----------------------------------|----------------------------------|-------------------------------|--------------------------------|---------------------------------|--------------------------------|---------------------------------|--------------------------------|----------------------------------|
| CWC | UA | Positive, R2=0.381, p=0.033 | Negative, R2=0.540, p=0.0065 | p>0.05 | p>0.05 | Negative, R=0.369, p=0.036 | p>0.05 | Positive, R2=0.834, p=0.00003 | Negative, R2=0.433, p=0.0199 | p>0.05 | p>0.05 | Positive, R2=0.905, p=0.000002 | Negative, R2=0.649, p=0.0016 |
| | 7 | Positive, R2=0.480, p=0.013 | Positive, R2=840, p=0.00003 | p>0.05 | Positive, R2=0.490, p=0.011 | p>0.05 | p>0.05 | Positive, R2=0.525, p=0.0077 | Positive, R2=0.386, p=0.031 | p>0.05 | Positive, R2=836, p=0.00003 | Positive, R2=0.755, p=0.00025 | Negative, R2=0.725, p=0.0004 |
| | 5.5 | p>0.05 | Positive, R2=0.894, 0.000004 | p>0.05 | Positive, R2=0.735, p=0.00036 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | Positive, R2=847, p=0.0.00002 | p>0.05 | Negative, R2=0.972, p=0.00000004 |
| | 4 | p>0.05 | Positive, R2=0.866, p=0.00001 | p>0.05 | Positive, R2=0.846, p=0.00002 | Positive, R2=0.663, p=0.0013 | Negative, R2=0.856, p=0.00001 | p>0.05 | p>0.05 | Negative, R2=0.342, p=0.046 | Positive, R2=782, p=0.0001 | Positive, R2=0.838, p=0.00003 | Negative, R2=0.918, p=0.0000009 |
| WT | UA | Negative, R2=0.651, p=0.0003 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | Positive, R2=0.845, p=0.000001 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | p>0.05 |
| | 7 | Negative, R2=0.526, p=0.008 | p>0.05 | Negative, R2=0.519, p=0.008 | Positive, R2=0.927, p=0.0000005 | p>0.05 | Positive, R2=0.531, p=0.007 | p>0.05 | Positive, R2=0.946, p=0.0000001 | p>0.05 | Positive, R2=0.943, p=0.0000002 | Negative, R2=0.728, p=0.0004 | p>0.05 |
| | 5.5 | Negative, R2=0.715, p=0.004 | p>0.05 | Negative, R2=0.919, p=0.00005 | Positive, R2=0.826, p=0.0007 | p>0.05 | Negative, R2=976, p=0.0000006 | Positive, R2=758, p=0.0022 | Positive, R2=0.750, p=0.0026 | Negative, R2=0.954, p=0.000006 | Positive, R2=0.956, p=0.000005 | p>0.05 | Negative, R2=0.972, p=0.000001 |
| | 4 | Positive, R2=0.802, p=0.00008 | p>0.05 | Negative, R2=0.695, p=0.0008 | Positive, R2=0.875, p=0.000005 | Positive, R2=0.966, p=0.00000001 | Negative, R2=0.713, p=0.0006 | Positive, R2=483, p=0.012 | Positive, R2=0.679, p=0.00099 | p>0.05 | Positive, R2=0.983, p=3x10-10 | Positive, R2=0.799, p=0.00009 | Negative, R2=0.547, p=0.0060 |
| DSS-1 | UA | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 7 | p>0.05 | Positive, R2=0.475, p=0.013 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | Negative, R2=0.885, p=0.000003 | p>0.05 | p>0.05 | p>0.05 | p>0.05 | p>0.05 |
| | 5.5 | p>0.05 | p>0.05 | Negative, R2=0.641, p=0.002 | Negative, R2=0.409, p=0.015 | p>0.05 | Positive, R2=490, p=0.011 | p>0.05 | p>0.05 | p>0.05 | Positive, R2=0.768, p=0.0002 | Positive, R2=0.376, p=0.034 | p>0.05 |
| | 4 | p>0.05 | Negative, R2=0.789, p=0.0001 | Negative, R2=0.763, p=0.0002 | Negative, R2=0.953, p=0.00000006 | Negative, R2=0.317, p=0.027 | Negative, R2=601, p=0.003 | p>0.05 | Negative, R2=0.860, p=0.00001 | Negative, R2=0.547, p=0.0060 | Positive, R2=0.691, p=0.0008 | p>0.05 | Negative, R2=0.775, p=0.00016 |
| DSS-2 | A | p>0.05 | p>0.05 | p>0.05 | Negative, R2=0.509, p=0.0091 | Negative, R2=0.691, p=0.0008 | Negative, R2=589, p=0.0036 | p>0.05 | p>0.05 | Negative, R2=0.714, p=0.00054 | Negative, R2=0.658, p=0.0014 | p>0.05 | Negative, R2=0.603, p=0.0030 |

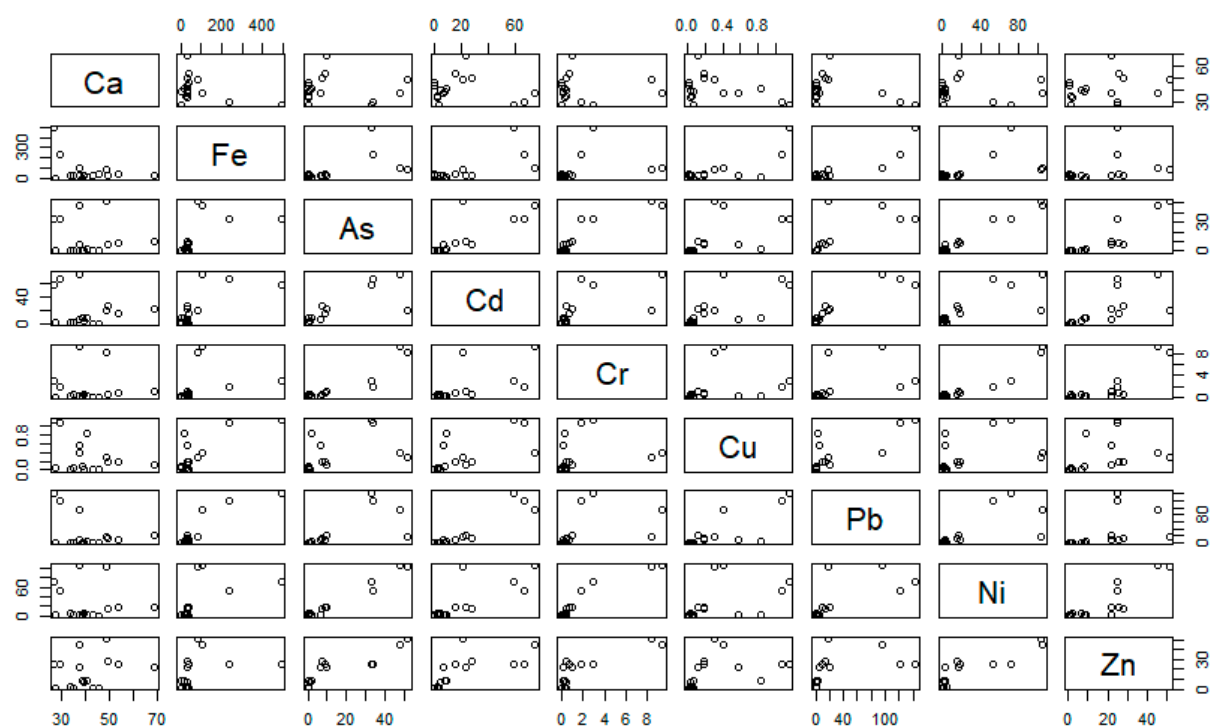
| | | | | | | | | | | | | | |
|--|-----|-------------------------------------|---------------------------------------|-----------------------------------|--------------------------------------|-----------------------------------|------------------------------------|--------|-------------------------------------|------------------------------------|-------------------------------------|--------|--------------------------------------|
| | 7 | Negative, R2=0.492, p=0.011 | Negative, R2=0.764, p=0.00020 | Negative, R2=0.615, p=0.003 | Negative, R2=0.885, p=0.000005 | p>0.05 | Negative, R2=0.606, p=0.0028 | p>0.05 | Negative, R2=0.360, p=0.0392 | Negative, R2=0.508, p=0.0093 | Negative, R2=0.807, p=0.00007 | p>0.05 | Negative, R2=0.0669, p=0.0012 |
| | 5.5 | Negative, R2=0.554, p=0.005 | Negative, R2=0.940, p=0.0000002 | Negative, R2=0.629, p=0.002 | Negative, R2=0.570, p=0.0045 | Negative, R2=0.405, p=0.026 | Negative, R2=0.632, p=0.0020 | p>0.05 | Negative, R2=0.504, p=0.0097 | Negative, R2=0.520, p=0.0082 | Negative, R2=0.785, p=0.00012 | p>0.05 | Negative, R2=0.810, p=0.00007 |
| | 4 | Negative, R2=0.869, p=0.00001 | Negative, R2=0.885, p=0.000003 | Negative, R2=0.645, p=0.002 | Negative, R2=0.725, p=0.0004 | p>0.05 | Negative, R2=0.589, p=0.0036 | p>0.05 | Negative, R2=0.752, p=0.00026 | Negative, R2=0.595, p=0.0033 | p>0.05 | p>0.05 | Negative, R2=0.875, p=0.000008 |

Figure S.4. Correlation matrix for elements (Ca, Fe, As, Cd, Cr, Cu, Pb, Ni, Zn) in eluates from leaching tests done at different pH levels (unaltered, 7, 5.5 and 4) for all biochars (CWC, WT, DSS-1, DSS-2).



| | Ca | Fe | As | Cd | Cr | Cu | Pb | Ni | Zn |
|----|-------------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|-----------|
| Ca | 1.00000000 | 0.1726529 | 0.1540811 | 0.2354766 | 0.2876173 | 0.1307351 | 0.009698289 | 0.3505022 | 0.5821665 |
| Fe | 0.172652870 | 1.0000000 | 0.5093697 | 0.5084934 | 0.4092420 | 0.6686050 | 0.750466534 | 0.5914883 | 0.4556349 |
| As | 0.154081073 | 0.5093697 | 1.0000000 | 0.7024839 | 0.7679087 | 0.4170927 | 0.733251616 | 0.8574555 | 0.7457586 |
| Cd | 0.235476573 | 0.5084934 | 0.7024839 | 1.0000000 | 0.6505961 | 0.4502810 | 0.733659374 | 0.7696494 | 0.7118083 |
| Cr | 0.287617302 | 0.4092420 | 0.7679087 | 0.6505961 | 1.0000000 | 0.3231032 | 0.484405150 | 0.9121694 | 0.8103151 |
| Cu | 0.130735073 | 0.6686050 | 0.4170927 | 0.4502810 | 0.3231032 | 1.0000000 | 0.565331221 | 0.4558357 | 0.4383954 |
| Pb | 0.009698289 | 0.7504665 | 0.7332516 | 0.7336594 | 0.4844052 | 0.5653312 | 1.000000000 | 0.6517857 | 0.4989957 |
| Ni | 0.350502185 | 0.5914883 | 0.8574555 | 0.7696494 | 0.9121694 | 0.4558357 | 0.651785695 | 1.0000000 | 0.8913529 |
| Zn | 0.582166501 | 0.4556349 | 0.7457586 | 0.7118083 | 0.8103151 | 0.4383954 | 0.498995688 | 0.8913529 | 1.0000000 |

Figure S.5. Correlation matrix for elements (Ca, Fe, As, Cd, Cr, Cu, Pb, Ni, Zn) in eluates from leaching tests done at pH 4 for all biochars (CWC, WT, DSS-1, DSS-2).



| | Ca | Fe | As | Cd | Cr | Cu | Pb | Ni | Zn |
|----|--------------|------------|-------------|------------|-------------|------------|------------|-------------|-----------|
| Ca | 1.000000000 | -0.3990446 | -0.07142635 | -0.1845403 | 0.005233809 | -0.3820412 | -0.3731715 | -0.07908247 | 0.2399463 |
| Fe | -0.399044625 | 1.0000000 | 0.57413786 | 0.7044071 | 0.311129512 | 0.7609935 | 0.8996154 | 0.57196318 | 0.3385140 |
| As | -0.071426347 | 0.5741379 | 1.000000000 | 0.8035358 | 0.917105358 | 0.5174615 | 0.7223836 | 0.98891425 | 0.8825131 |
| Cd | -0.184540301 | 0.7044071 | 0.80353581 | 1.0000000 | 0.640554493 | 0.6652383 | 0.9297767 | 0.79536474 | 0.6894270 |
| Cr | 0.005233809 | 0.3111295 | 0.91710536 | 0.6405545 | 1.000000000 | 0.2381353 | 0.4918835 | 0.94590654 | 0.8346080 |
| Cu | -0.382041238 | 0.7609935 | 0.51746151 | 0.6652383 | 0.238135296 | 1.0000000 | 0.7804432 | 0.46236512 | 0.3918110 |
| Pb | -0.373171460 | 0.8996154 | 0.72238357 | 0.9297767 | 0.491883490 | 0.7804432 | 1.0000000 | 0.71069741 | 0.5032303 |
| Ni | -0.079082472 | 0.5719632 | 0.98891425 | 0.7953647 | 0.945906545 | 0.4623651 | 0.7106974 | 1.00000000 | 0.8673925 |
| Zn | 0.239946279 | 0.3385140 | 0.88251313 | 0.6894270 | 0.834607985 | 0.3918110 | 0.5032303 | 0.86739251 | 1.0000000 |

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