# **Table S1.** Summary of biochar and soil properties and percentage change in bulk density and water retention from reviewed studies.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Reference | Biochar properties | | | | |  | Soil properties | | Percent change in density and water retention | | | |
| Feedstock | Temp  (°C) | PS  (mm) | C  (%) | Rate  (%) | Exp. Type,  Duration (days) | Texture | C (%) | BD | *FC* | *WP* | *AW* |
| Xiu *et al.* (2019) | Corn straw | 450 | 3.5 | 50.6 | 3.00 | PT, 730 | LS | 0.65 | −9.6 | 9.1 | – | – |
| Wang *et al.* (2019) | Softwood | 700 | 2.0 | 68.2 | 1.00 | PT, <5 | CL | – | – | −1.6 | – | – |
| 700 | 2.0 | 68.2 | 1.00 | PT, <5 | SL | – | – | 5.0 | – | – |
| Walnut shell | 900 | 2.0 | 55.3 | 1.00 | PT, <5 | CL | – | – | 1.6 | 0.0 | −9.9 |
| 900 | 2.0 | 55.3 | 1.00 | PT, <5 | SL | – | – | 17.5 | 8.5 | 57.1 |
| 900 | 2.0 | 55.3 | 0.51 | FD, 2190 | SiCL | 2.00 | – | 3.7 | 1.5 | 6.1 |
| Jin *et al.* (2019) | Wheat straw | – | 2.0 | 46.7 | 1.08 | FD, 365 | CL | 0.90 | −13.5 | 12.8 | 0.9 | 27.3 |
| – | 2.0 | 46.7 | 2.17 | FD, 365 | CL | 0.90 | −32.3 | 22.8 | −0.6 | 51.3 |
| – | 2.0 | 46.7 | 1.08 | FD, 1825 | CL | 0.85 | −2.9 | 3.4 | 0.7 | 6.8 |
| – | 2.0 | 46.7 | 2.17 | FD, 1825 | CL | 0.85 | −8.7 | 7.3 | −3.8 | 22.0 |
| Fu *et al.* (2019) | Corn straw | 500 | 2.0 | 70.4 | 2.16 | FD, 210 | L |  | – | 3.5 | −21.7 | 74.2 |
| Bohara *et al.* (2019) | Pinewood chips | 550 | – | – | 2.50 | PT, 56 | SL | – | – | 9.8 | 6.8 | 11.1 |
| Baiamonte *et al.* (2019) | Forest waste | 450 | 2.0 | 43.5 | 9.10 | LB, <5 | S | 0.27 | −38.4 | 11.5 | 20.0 | 0.0 |
| Alkhasha *et al.* (2018) | Palm residues | 450 | 2.0 | – | 6.00 | LB, 35 | LS | 0.23 | – | 9.8 | −1.0 | 13.5 |
| Singh *et al.* (2018) | Rice husk | 300 | 2.0 | 40.0[[1]](#footnote-1) | 0.56 | FD, 105 | S | 0.61 | −4.2 | 24.5 | – | – |
| Alghamdi *et al.* (2018) | Palm leaves | 450 | 2.0 | 39.5[[2]](#footnote-2) | 3.00 | LB, 35 | S | – | – | 27.8 | 150 | 18.8 |
| Gunal *et al.* (2018) | Rice husk | 500 | 2.0 | 56.0 | 3.00 | GH, 220 | L | 0.65 | −7.8 | 5.4 | 5.8 | 5.30 |
| 500 | 2.0 | 56.0 | 3.00 | GH, 220 | SL | 0.44 | −4.8 | 11.0 | 6.4 | 14.9 |
| Igaz *et al.* (2018) | Paper fiber sludge, cereal husk | 550 | – | 53.1 | 1.25 | FD, 570 | SiL | 1.26 | 0.0 | 2.3 | −4.8 | 38.9 |
| Obia *et al.* (2018) | Crofton weed | 550 | – | 71.4 | 2.50 | PT, 14 | C | 3.80 | −0.7 | 15.0 | 0.0 | 37.5 |
| Paetsch *et al.* (2018) | Maize silage | 1200 | – | 69.5 | 1.41 | PT, <5 | L | 0.14 | – | 5.5 | 4.5 | 5.9 |
| 1200 | – | 69.5 | 1.41 | PT, 1095 | L | 0.14 | – | 2.7 | 9.1 | 0.0 |
| Rasa *et al.* (2018) | Willow stem | 320 | – | 74.0 | 5.00 | PT, 42 | C | 4.60 | – | 13.9 | −7.7 | 31.8 |
| Villagra-Mendoza and Horn (2018) | Mango tree | 600 | 0.1 | 78.4 | 2.50 | PT, <5 | S | 0.16 | – | 80.0 | 85.5 | 79.3 |
| 600 | 0.1 | 78.4 | 2.50 | PT, <5 | SL | 1.35 | – | 4.5 | 1.9 | 5.9 |
| Zong *et al.* (2018) | Wastewater sludge | – | 2.0 | 47.7 | 4.00 | PT, 240 | C | 1.09 | – | −6.3 | −14.0 | 21.4 |
| – | 2.0 | 47.7 | 4.00 | PT, 240 | SL | 2.13 | – | 10.5 | 2.5 | 19.4 |
| Lima *et al.* (2018) | Coffee ground | 530 | – | 67.1 | 0.27 | GH, 45 | S | 1.60 | – | 26.4 | 0.0 | 28.6 |
| Coffee husk | 530 | – | 68.8 | 0.27 | GH, 45 | S | 1.60 | – | 49.4 | 50.0 | 42.9 |
| Glab *et al.* (2018) | Willow | 350 | – | 38.2 | 4.00 | PT, 120 | LS | – | −11.1 | 127.3 | 231.9 | 39.9 |
| Trifunovic *et al.* (2018) | Pine wood | 300 | 2.0 | 86.0 | 10.0 | PT, <5 | S | – | −17.4 | 338.9 | – | – |
| Mohan *et al.* (2018) | Corn stover | 650 | 2.0 | 77.5 | 1.50 | PT, 107 | SiL | 0.48 | – | 73.2 | – | – |
| Rice husk | 550 | 2.0 | 74.4 | 1.50 | PT, 107 | SiL | 0.48 | – | 47.3 | – | – |
| Kerre *et al.* (2017)[[3]](#footnote-3) | – | – | – | – | 2.20[[4]](#footnote-4) | FD, >150 years | SiL | 2.00 | – | 9.8 | 7.7 | 10.7 |
| Aller *et al.* (2017) | Corn stover | 500 | 1.0 | 49.9 | 1.00 | GH, 30 | SL | 1.25 | −1.9 | −7.9 | – | −88.2 |
| 500 | 1.0 | 49.9 | 1.00 | GH, 30 | SiL | 2.89 | −3.3 | −2.1 | – | 0.0 |
| 500 | 1.0 | 49.9 | 1.00 | GH, 30 | CL | 4.86 | −1.8 | −14.5 | – | −4.2 |
| Hardwood | 550 | 1.0 | 36.2 | 1.00 | GH, 30 | SL | 1.25 | – | – | – | 5.9 |
| 550 | 1.0 | 36.2 | 1.00 | GH, 30 | SiL | 2.89 | – | – | – | −12.5 |
| 550 | 1.0 | 36.2 | 1.00 | GH, 30 | CL | 4.86 | – | – | – | −5.6 |
| Switchgrass | 500 | 1.0 | 20.5 | 1.00 | GH, 30 | SL | 1.25 | – | – | – | 10.6 |
| 500 | 1.0 | 20.5 | 1.00 | GH, 30 | SiL | 2.89 | – | – | – | 0.0 |
| 500 | 1.0 | 20.5 | 1.00 | GH, 30 | CL | 4.86 | – | – | – | 0.0 |
| Amoakwah *et al.* (2017) | Corn cob | 550 | 2.0 | 38.8 | 0.68 | FD, 180 | SL | 1.03 | −4.6 | 9.1 | −3.5 | 28.2 |
| Arthur and Ahmed (2017) | Rice straw | 550 | 2.0 | 25.4 | 3.00 | FD, 450 | S | 0.34 | −12.6 | 90.8 | – | – |
| Kelly *et al.* (2017) | Switchgrass | 550 | 2.0 | 71.7 | 10.0 | PT, 56 | C | 1.04 | – | −8.0 | −30.0 | 80.0 |
| 550 | 2.0 | 71.7 | 10.0 | PT, 56 | C | 4.06 | – | 11.3 | −6.7 | 21.5 |
| Madari *et al.* (2017) | Savanna wood | 350 | 2.0 | 51.0 | 1.14 | FD, 1825 | SCL | 2.10 | 5.7 | −6.7 | 16.7 | −22.2 |
| Moragues-Saitua *et al.* (2017) | Miscanthus | 450 | – | 85.8 | 0.95 | FD, 900 | L | 3.90 | −23.8 | 16.2 | −5.9 | 35.0 |
| 450 | – | 85.8 | 0.95 | FD, 450 | SL | 10.80 | 7.1 | −15.6 | −9.1 | −19.3 |
| Obia et al. (2017) | Corn cob | 350 | 0.5 | 44.8 | 3.40 | FD, 730 | LS | 0.60 | −3.4 | −37.5 | – | – |
| 350 | 5.0 | 60.1 | 3.40 | FD, 730 | LS | 0.60 | −8.2 | 100.0 | – | – |
| 350 | 0.5 | 44.8 | 4.00 | FD, 730 | SL | 0.74 | −4.7 | 5.4 | – | – |
| 350 | 5.0 | 60.1 | 4.00 | FD, 730 | SL | 0.74 | −9.4 | −4.2 | – | – |
| Ajayi and Horn (2017) | Woodchip | 550 | 0.8 | 77.5 | 5.00 | LB, 100 | SL | 0.92 | −0.7 | – | – | 16.2 |
| 550 | 0.8 | 77.5 | 5.00 | LB, 100 | S | – | −3.0 | – | – | 18.8 |
| Amendola *et al.* (2017) | Orchard | 500 | 2.0 | 77.8 | 0.71 | FD, 365 | C | 1.16 | – | – | – | 14.7 |
| Deng *et al.* (2017) | Acacia seyal | – | – | 69.0 | 0.71 | FD, 450 | SiL | 0.58 | – | 38.1 | 200.0 | 30.0 |
| Kameyama *et al.* (2017) | Wood−based | 400 | – | 72.0 | 2.00 | FD, – | S | – | – | – | – | 37.5 |
| Suliman *et al.* (2017) | Hybrid poplar wood | 350 | 0.4 | 69.9 | 2.00 | LB, – | S | 0.38 | −14.1 | 69.6 | 14.5 | 94.9 |
| 600 | 0.4 | 83.1 | 2.00 | LB, – | S | 0.38 | −14.8 | 50.8 | 27.6 | 61.4 |
| Liu *et al.* (2016) | Mixed crops straw | 500 | – | 83.4 | 1.33 | FD, – | L | 0.72 | −8.3 | 0.0 | 0.0 | 19.1 |
| Ajayi *et al.* (2016) | Woodchips and forest residues | 550 | 0.6 | 77.5 | 5.00 | LB, 30 | S | 0.07 | −1.9 | 24.1 | 125.0 | 19.0 |
| Burrell *et al.* (2016) | Wheat straw | 525 | 2.0 | – | 3.00 | PT, 730 | SL | – | −18.2 | 18.3 |  |  |
| Woodchips | 525 | 2.0 | – | 3.00 | PT, 730 | SL | – | −13.3 | 10.6 | −5.4 | 37.8 |
| Vineyard-prunings | 525 | 2.0 | – | 3.00 | PT, 730 | SL | – | −11.2 | 13.0 | 21.6 | 1.5 |
| Woodchips | 525 | 2.0 | – | 3.00 | PT, 730 | SiL | – | −10.3 | 4.5 | −2.7 | 25.9 |
| 525 | 2.0 | – | 3.00 | PT, 730 | CL | – | −9.9 | 1.9 | 1.2 | 7.9 |
| Carvalho *et al.* (2016) | Eucalyptus spp. | 475 | 2.0 | 75.9 | 1.60 | FD, 1095 | C | 1.60 | −8.7 | −14.0 | −11.1 | −21.4 |
| Esmaeelnejad *et al.* (2016) | Apple-wood chips | 550 | 1.0 | 83.8 | – | LB, 180 | SL | – | −0.7 | 52.2 | 38.0 | 97.0 |
| 550 | 2.0 | 83.8 | – | LB, 180 | SL | – | −0.7 | 78.3 | 64.0 | 51.5 |
| Rice husk | 350 | 1.0 | 38.9 | – | LB, 180 | SL | – | −1.9 | 41.3 | 43.0 | 51.5 |
| 350 | 2.0 | 38.9 | – | LB, 180 | SL | – | −2.5 | 41.3 | 40.0 | 51.5 |
| 550 | 1.0 | 41.5 | – | LB, 180 | SL | – | −2.0 | 58.7 | 47.0 | 66.7 |
| 550 | 2.0 | 41.5 | – | LB, 180 | SL | – | −0.7 | 45.7 | 38.0 | 51.5 |
| Gamage *et al.* (2016) | Rice husk | 600 | 1.6 | – | 1.00 | LB, 180 | S | 0.86 | −14.2 | 100.0 | – | – |
| 600 | 1.6 | – | 1.00 | LB, 180 | SL | 0.80 | −12.1 | 22.2 | – | – |
| Glab *et al.* (2016) | Wheat straw | 300 | 0.5 | 63.3 | 0.50 | PT, 90 | LS | – | −7.8 | 6.8 | −18.1 | 17.3 |
| 300 | 0.5 | 63.3 | 4.00 | PT, 90 | LS | – | −20.0 | 147.7 | 37.1 | 190.9 |
| 300 | 2.0 | 63.3 | 0.50 | PT, 90 | LS | – | −14.4 | 29.5 | 39.7 | 27.4 |
| 300 | 2.0 | 63.3 | 4.00 | PT, 90 | LS | – | −31.1 | 136.4 | 321.6 | 71.4 |
| Miscanthus straw | 300 | 0.5 | 65.9 | 0.50 | PT, 90 | LS | – | −10.6 | 22.7 | −47.4 | 50.6 |
| 300 | 0.5 | 65.9 | 4.00 | PT, 90 | LS | – | −23.3 | 161.4 | 1.7 | 220.1 |
| 300 | 2.0 | 65.9 | 0.50 | PT, 90 | LS | – | −10.0 | 29.5 | −6.0 | 43.1 |
| 300 | 2.0 | 65.9 | 4.00 | PT, 90 | LS | – | −25.0 | 118.2 | 221.6 | 84.3 |
| Hansen *et al.* (2016) | Wheat straw | 750 | 1.0 | 46.8 | 1.00 | PT, 42 | SL | 1.70 | – | 7.7 | −4.8 | 16.7 |
| Pine | 1200 | 1.0 | 65.3 | 1.00 | PT, 42 | SL | 1.70 | – | 15.4 | 14.3 | 16.7 |
| Wheat straw | 750 | 1.0 | 46.8 | 1.00 | PT, 42 | S | 0.15 | – | 50.0 | 10.0 | 50.0 |
| Pine | 1200 | 1.0 | 65.3 | 1.00 | PT, 42 | S | 0.15 | – | 49.2 | 25.0 | 30.0 |
| Kameyama *et al.* (2016) | Sugarcane bagasse | 400 | 2.0 | 65.4 | – | LB, – | C | 1.34 | −14.3 | −8.1 | −15.2 | 50.0 |
| 600 | 2.0 | 75.3 | – | LB, – | C | 1.34 | −13.3 | −5.4 | −12.1 | 50.0 |
| 800 | 2.0 | 79.4 | – | LB, – | C | 1.34 | −12.4 | −5.4 | −12.1 | 50.0 |
| Ma *et al.* (2016) | Maize straw and peanut hulls | – | – | 64.0 | 0.38 | FD, 1460 | CL | 1.87 | −8.8 | 5.9 | 3.8 | 10.8 |
| Obia *et al.* (2016) | Rice husk | 350 | 0.5 | 39.3 | 4.00 | FD, 730 | SL | 0.67 | −7.1 | 12.8 | 7.7 | 14.7 |
| 350 | 0.5 | 39.3 | 3.40 | FD, 730 | S | 0.62 | −8.6 | 1.3 | 23.5 | 0.0 |
| Petersen *et al.* (2016) | Wheat straw | 750 | 0.1 | – | 2.00 | LB, 1 | S | 0.15 | – | 91.7 | 75.0 | 100.0 |
| Sludge, straw, shea nut shell | 750 | 0.1 | – | 2.00 | LB, 1 | S | 0.15 | – | 96.7 | 75.0 | 107.5 |
| Wheat straw | 550 | 0.2 | – | 2.00 | LB, 1 | S | 0.15 | – | 41.7 | 33.3 | 50.0 |
| Pratiwi and Shinogi (2016) | Rice husk | – | – | 41.0 | 4.00 | PT, 100 | L | 1.71 | −12.4 | 8.3 | −1.7 | 20.7 |
| Xiao *et al.* (2016) | Maize | 400 | – | 59.2 | 1.10 | FD, 730 | L | 0.20 | −11.0 | – | – | 9.9 |
| Zong *et al.* (2016) | Wheat straw | 500 | 2.0 | 50.2 | 2.00 | LB, 180 | CL | 0.24 | – | 22.9 | 21.5 | 26.4 |
| Baiamonte *et al.* (2015) | Poplar woodchips | 1200 | 2.0 | – | 9.00 | LB, 0 | SC | – | – | – | 3.2 | 97.8 |
| Bayabil *et al.* (2015) | Oak | 450 | – | – | 5.00 | PT, 30 | C | 1.11 | – | −4.7 | – | −12.7 |
| Jeffery *et al.* (2015) | Herbaceous plant cuttings | 600 | – | 59.0 | 0.67 | FD, 730 | S | 2.70 | – | 3.6 | 2.9 | 5.4 |
| 400 | – | 59.0 | 1.33 | FD, 365 | S | 2.70 | – | 0.0 | 25.0 | 3.0 |
| Mollinedo *et al.* (2015) | Corn stover | 650 | 2.0 | 73.6 | 4.00 | LB, 1 | SL | – | – | 21.4 | 0.0 | 27.8 |
| Switchgrass | 650 | 2.0 | 76.1 | 4.00 | LB, 1 | SL | – | – | 17.9 | −9.1 | 27.8 |
| Corn stover | 650 | 2.0 | 73.6 | 4.00 | LB, 1 | CL | – | – | 20.0 | 6.3 | 31.6 |
| Alburquerque *et al.* (2014) | Pine woodchips | 507 | 2.0 | 80.0 | 2.50 | GH, 60 | LS | 0.90 | −5.4 | 27.3 | – | – |
| Olive-tree prunings | 507 | 2.0 | 48.3 | 2.50 | GH, 60 | LS | 0.90 | 0.6 | 0.4 | – | – |
| Ashworth *et al.* (2014) | Switchgrass | 400 | – | – | 0.18 | FD, 365 | SiL | – | −3.5 | −4.0 | – | – |
| Baronti *et al.* (2014) | Orchard pruning biomass | 500 | 2.0 | 77.8 | 0.50 | FD, 730 | SCL | 0.47 | −1.4 | 8.7 | – | 8.3 |
| Borchard *et al.* (2014) | Hard wood | 1100 | 2.0 | 82.9 | 1.50 | PT, 826 | S | 0.73 | – | −3.0 | – | – |
| Soft wood | 500 | 2.0 | 79.5 | 1.50 | PT, 826 | S | 0.73 | – | 0.0 | – | – |
| Hard wood | 550 | 2.0 | 87.5 | 1.50 | PT, 826 | Si | 1.20 | – | 0.0 | – | – |
| Soft wood | 500 | 2.0 | 79.5 | 1.50 | PT, 826 | Si | 1.20 | – | 0.0 | – | – |
| Hardie *et al.* (2014) | Tree green waste | 550 | 3.8 | – | 3.70 | FD, 930 | SL | 2.42 | −11.0 | 5.6 | −14.3 | 14.5 |
| Ippolito *et al.* (2014) | Oak and hickory hardwood | 500 | – | 66.2 | 10.00 | PT, 360 | Si | 1.20 | – | 14.0 | 0.9 | 29.3 |
| Martinsen *et al.* (2014) | Maize cobs | 350 | 2.0 | 69.7 | 5.00 | LB, – | S | 0.58 | −9.3 | 114.0 | 83.3 | 122.2 |
| 350 | 2.0 | 69.7 | 5.00 | LB, – | LS | 0.54 | −13.0 | 20.2 | 23.1 | 19.7 |
| 350 | 2.0 | 81.1 | 5.00 | LB, – | SL | 0.62 | −9.9 | 18.2 | 3.3 | 22.5 |
| Mukherjee *et al.* (2014) | Oak wood | 650 | 2.0 | – | 0.50 | FD, 730 | SiCL | 2.30 | −23.5 | – | – | – |
| Peake *et al.* (2014) | Corsican Pine woodmill waste | 450 | – | – | 0.50 | PT, – | LS | 1.51 | −3.2 | 6.1 | – | 17.9 |
| 450 | – | – | 0.50 | PT, – | SL | 1.74 | −0.6 | −5.9 | – | 4.0 |
| 450 | – | – | 0.50 | PT, – | SL | 1.86 | −8.9 | 24.1 | – | 31.9 |
| 450 | – | – | 0.50 | PT, – | L | 1.04 | −4.2 | 10.2 | – | 7.1 |
| 450 | – | – | 0.50 | PT, – | SiL | 1.39 | −4.3 | −1.6 | – | −5.8 |
| Quin *et al.* (2014) | Oil mallee trees | 550 | 2.0 | 59.9 | 1.00 | LB, 280 | C | 2.25 | −2.1 | −2.6 | 0.0 | −6.7 |
| 550 | 2.0 | 59.9 | 1.00 | LB, 280 | C | 4.39 | −1.1 | 0.0 | 0.0 | 0.0 |
| Rogovska *et al.* (2014) | Oak, elm, hickory | 575 | 0.2 | 78.0 | 1.58 | FD, 420 | L | 1.31 | −9.3 | 14.5 | – | 150.0 |
| Sun and Lu (2014) | Crop straw | 500 | 0.3 | 50.2 | 4.00 | LB, 180 | C | 0.76 | −7.1 | 17.5 | 28.6 | 5.0 |
| Woodchips | 500 | 0.3 | 37.9 | 4.00 | LB, 180 | C | 0.76 | −23.2 | 5.3 | 22.9 | −5.0 |
| Wastewater sludge | 500 | 0.3 | 47.7 | 4.00 | LB, 180 | C | 0.76 | −1.0 | −1.8 | 0.0 | −2.0 |
| Tammeorg *et al.* (2014) | Spruce chips | 575 | – | 88.3 | 3.00 | FD, 120 | LS | 3.15 | 4.0 | 14.3 | 6.8 | 16.4 |
| 575 | – | 88.3 | 3.00 | FD, 480 | LS | 3.15 | −15.7 | −4.7 | −10.1 | −2.8 |
| Ulyett *et al.* (2014) | Sycamore, oak, beech, bird cherry. | 600 | 2.0 | 75.1 | 2.99 | LB, 60 | SL | 1.54 | −7.0 | 6.1 | – | – |
| 600 | 2.0 | 75.1 | 2.99 | LB, 60 | SL | 0.83 | −6.4 | 4.5 | – | – |
| Abel *et al.* (2013) | Maize plant | 750 | 2.0 | 56.9 | 2.50 | LB, 0 | S | 0.50 | −8.7 | – | – | 12.9 |
| 750 | 2.0 | 56.9 | 2.50 | LB, 0 | LS | 0.75 | −15.3 | – | – | 6.7 |
| 750 | 2.0 | 56.9 | 2.50 | LB, 0 | LS | 0.65 | −11.3 | – | – | 40.6 |
| 750 | 2.0 | 56.9 | 2.50 | LB, 0 | LS | 4.55 | −9.0 | – | – | −17.6 |
| Beech wood | 550 | 5.0 | 78.0 | 2.50 | FD, 180 | LS | 1.05 | −7.7 | 18.8 | 0.0 | 27.6 |
| Alburquerque *et al.* (2013) | Wheat straw | 370 | 2.0 | 62.8 | 2.50 | PT, 60 | LS | 0.08 | −4.5 | 12.9 | – | – |
| Herath *et al.* (2013) | Corn stover | 350 | 2.0 | 63.5 | 1.13 | LB, 295 | SiL | 3.81 | −5.0 | 5.9 | 12.8 | −3.9 |
| 550 | 2.0 | 71.8 | 1.00 | LB, 295 | SiL | 3.81 | −10.0 | 6.0 | 10.2 | −7.7 |
| 350 | 2.0 | 63.5 | 1.50 | LB, 295 | SiL | 9.65 | −2.9 | 10.9 | 6.3 | 20.7 |
| 550 | 2.0 | 71.8 | 1.33 | LB, 295 | SiL | 9.65 | −2.9 | 11.9 | 9.5 | 17.2 |
| Ibrahim *et al.* (2013) | Conocarpus wood | 400 | 0.2 | 76.8 | 2.00 | LB, 35 | SL | 0.55 | – | 13.2 | 8.1 | 15.2 |
| Karer *et al.* (2013) | Beech wood | 550 | 2.0 | 80.0 | 2.65 | FD, 480 | CL | 2.4 | −14.0 | 8.9 | 3.2 | 18.8 |
| Beech wood | 550 | 2.0 | 80.0 | 2.50 | FD, 480 | SiL | 1.87 | −19.4 | 18.3 | 6.7 | 32.3 |
| Lei and Zhang (2013) | Manure | 300 | 2.0 | 39.3 | 5.00 | LB, 180 | L | – | −6.9 | 4.8 | 21.4 | 4.7 |
| 500 | 2.0 | 19.0 | 5.00 | LB, 180 | L | – | −9.5 | 7.1 | 28.6 | 29.3 |
| 700 | 2.0 | 27.9 | 5.00 | LB, 180 | L | – | −8.6 | 11.9 | 50.0 | 39.9 |
| Woodchip | 300 | 2.0 | 51.2 | 5.00 | LB, 180 | L | – | −4.8 | 2.4 | 14.3 | 39.1 |
| 500 | 2.0 | 43.2 | 5.00 | LB, 180 | L | – | −5.4 | 9.5 | 35.7 | 51.1 |
| 700 | 2.0 | 31.1 | 5.00 | LB, 180 | L | – | −4.5 | 15.5 | 64.3 | 55.1 |
| Ouyang *et al.* (2013) | Dairy manure | 500 | 0.2 | 73.9 | 2.00 | LB, 20 | SL | 0.74 | – | 2.7 | −20.0 | 12.2 |
| 500 | 0.2 | 73.9 | 2.00 | LB, 20 | SiC | 1.17 | – | 2.5 | −22.2 | 5.9 |
| Sun *et al.* (2013) | Birch wood | 500 | 8.0 | 81.0 | 0.65 | FD, 211 | SL | 1.24 | −9.1 | 18.9 | 0.0 | 30.4 |
| Case *et al.* (2012) | Oak, cherry, | 400 | 2.0 | 72.3 | 5.00 | LB, 126 | SL | 1.42 | −8.4 | 11.5 | – | – |
| Kameyama *et al.* (2012) | Sugarcane bagasse | 500 | 2.0 | 78.4 | 5.00 | LB, 1 | C |  | −20.6 | −7.9 | – | – |
| Liu *et al.* (2012) | Charcoal residue | – | – | 62.7 | 1.33 | FD, – | LS | 0.80 | – | 70.0 | 10.0 | 100.0 |
| Major *et al.* (2012) | Wood species | 600 | 5.0 | 72.9 | 3.30 | FD, 360 | C | 2.01 | −8.3 | 4.2 | 9.1 | −11.8 |
| Novak *et al.* (2012) | Hardwood | 500 | 0.2 | 72.6 | – | LB, 127 | LS | 1.68 | −3.6 | 20.8 | 8.1 | 33.3 |
| Switchgrass | 500 | 0.2 | 84.4 | – | LB, 127 | SiL | 0.69 | −3.4 | 51.7 | 18.9 | 84.0 |
| Peanut hull | 500 | 0.2 | 81.8 | – | LB, 127 | SiL | 0.44 | −6.9 | 18.8 | 5.4 | 32.0 |
| Revell *et al.* (2012) | Chicken litter and pine shaving | 450 | 0.03 | 27.1 | 20.00 | GH, 166 | SL | – | – | 33.3 | – | – |
| 450 | 0.03 | 27.1 | 20.00 | GH, 166 | SiL | – | – | 10.0 | – | – |
| Streubel *et al.* (2011) | Softwood bark | 500 | – | – | 0.75 | LB, – | S | 0.43 | – | 0.0 | – | – |
| 500 | – | – | 0.75 | LB, – | SiL | 1.8 | – | 4.7 | – | – |
| 500 | – | – | 0.75 | LB, – | SiL | 2.32 | – | 14.9 | – | – |
| 500 | – | – | 0.75 | LB, – | SiL | 2.69 | – | 10.3 | – | – |
| 500 | – | – | 0.75 | LB, – | SiL | 3.99 | – | −1.7 | – | – |
| Uzoma *et al.* (2011) | Black locust | 400 | 0.2 | – | 0.89 | LB, – | S | – | – | 56.3 | 12.5 | 100.0 |
| Brockhoff *et al.* (2010) | Switchgrass | 500 | – | – | 10.00 | PT, 120 | S | – | – | 62.5 | – | 271.4 |
| Laird *et al.* (2010) | Oak and hickory | – | 0.5 | – | 1.00 | LB, 500 | L | – | −11.6 | 3.8 | 4.8 | 3.2 |

Temp, pyrolysis temperature; PS, biochar particle size; C, total organic carbon; Rate, biochar application rate; Exp. Type, experiment type; BD, bulk density; FC, water content at field capacity; WP, water content at permanent wilting point; AW, plant available water content [FC−WP]. Experimental Type: PT, pot experiment; FD, field experiment; LB, laboratory-based experiment; GH, greenhouse experiment. Soil texture: LS, loamy sand; CL, clay loam; SL, sandy loam; SiCL, silty clay loam; L, loam; S, sand; LS, loamy sand; SiL, silt loam; C, clay; SCL, sandy clay loam; SC, sandy clay; Si, silt.

# **Table S2.** Descriptive statistics of the biochar and soil characteristics and changes in soil density and water retention variables grouped according to soil textural classes.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Coarse−textured soils (*n* = 56)** | | | | | | |
| **Variable** | **Np** | **Mean** | **Q1** | **Median** | **Q3** | **Min** | **Max** |
| *A*rate | 55 | 2.73 | 1.00 | 2.50 | 3.40 | 0.27 | 10.00 |
| *C*b | 45 | 1.74 | 0.76 | 1.42 | 2.53 | 0.18 | 8.60 |
| *C*s | 41 | 0.94 | 0.34 | 0.62 | 0.90 | 0.07 | 4.55 |
| ΔBD | 37 | −11.19 | −14.44 | −9.63 | −5.41 | −38.44 | 4.00 |
| ΔFC | 50 | 50.09 | 9.28 | 27.53 | 77.50 | −37.50 | 338.89 |
| ΔWP | 35 | 47.34 | 2.33 | 23.08 | 62.50 | −47.41 | 321.55 |
| ΔAW | 43 | 52.86 | 17.58 | 33.33 | 75.33 | −17.65 | 271.43 |
|  | **Medium−textured soils (*n* = 83)** | | | | | | |
| *A*rate | 76 | 2.71 | 1.00 | 1.50 | 3.78 | 0.18 | 20.00 |
| *C*b | 57 | 1.50 | 0.65 | 1.12 | 1.96 | 0.21 | 5.42 |
| *C*s | 58 | 1.89 | 0.70 | 1.29 | 2.08 | 0.01 | 10.80 |
| ΔBD | 53 | −6.53 | −9.48 | −6.37 | −2.86 | −23.81 | 7.14 |
| ΔFC | 78 | 14.98 | 4.68 | 10.25 | 18.26 | −15.56 | 78.26 |
| ΔWP | 53 | 11.45 | 0.00 | 6.70 | 18.92 | −21.74 | 64.29 |
| ΔAW | 68 | 24.04 | 5.88 | 18.16 | 35.69 | −88.24 | 150.00 |
|  | **Fine−textured soils (*n* =37)** | | | | | | |
| *A*rate | 37 | 2.91 | 1.00 | 2.17 | 4.00 | 0.38 | 10.00 |
| *C*b | 34 | 1.90 | 0.56 | 1.40 | 2.22 | 0.21 | 7.17 |
| *C*s | 32 | 2.03 | 1.08 | 1.34 | 2.33 | 0.76 | 4.86 |
| ΔBD | 21 | −10.87 | −13.97 | −8.82 | −2.90 | −32.33 | −0.66 |
| ΔFC | 33 | 2.78 | −4.69 | 1.91 | 8.89 | −14.55 | 22.80 |
| ΔWP | 27 | −2.03 | −9.40 | 0.00 | 2.23 | −30.00 | 28.57 |
| ΔAW | 33 | 14.28 | −4.17 | 6.80 | 29.29 | −21.95 | 80.00 |

Np, number of publications; *A*rate, application rate; *C*b, added biochar carbon; *C*S, initial soil carbon content; ΔBD, change in bulk density, ΔFC, change in field capacity water content, ΔWP, change in wilting point water content, ΔAW, change in plant available water content. The number of studies used for the analyses in each soil textural group is denoted by *n*.

1. Calculated from ash content [↑](#footnote-ref-1)
2. Estimated from OM of 79% [↑](#footnote-ref-2)
3. Study on historical charcoal kilns from 1800s [↑](#footnote-ref-3)
4. Biochar−C concentration in black spots of the field [↑](#footnote-ref-4)