Supporting information

Elemental contents

The elemental content in the samples was determined according to the method by McGrath and Cunliffe [1]. Briefly, the air-dried sample was ground to achieve a powder form and 0.25 mg of the powdered sample was weighed and transferred into a digestion vessel. Then, 6 mL of concentrated HCl and 2 mL of HNO_3 were added and the mixture was digested at 110^{o}C. The resulting solution was cooled and then a further 10 mL of 1.2 % HNO_3 was added. The solution was reheated to 80^{o}C for 30 minutes and then made up to 20 mL with Millipore water after which the solution was vortexed then filtered through a Whatman No. 42 filter paper into a plastic vial. The concentration of elements in the solution was measured using Optima 8300 DV, Perkin Elmer ICP-OES.

Quantitative determination of surface acidic functional groups

The surface acid functional groups of the EFBB samples were determined by Boehm titration method [1,2]. Briefly, 0.2 g of the EFBB sample was added with 20 mL of either 0.05 M $NaHCO_3$, 0.1 M Na_2CO_3 or 0.1 M NaOH. Then the mixture along with a control solution without any biochar sample were shaken for 24 h and then filtered through a Whatman No. 42 filter paper to remove the solid particles. Then, 10 mL aliquot from each filtrate was mixed with 15 mL of excess 0.1 M HCl to ensure complete neutralization of the bases and then the solution was back-titrated with 0.1 M NaOH solution using phenolphthalein as an indicator. The total surface acidity was calculated as the moles neutralized by NaOH, the carboxy group as the moles neutralized by $NaHCO_3$, and the lacton group was calculated as the difference between values obtained from the $NaHCO_3$ and Na_2CO_3 titrations. The difference between molar NaOH and Na_2CO_3 was assumed to be the phenolic group contents as described by Rutherford *et al.* [4].

Cation exchange capacity

The cation exchange capacity (CEC) of the EFBB samples was determined by a compulsive exchange method [5] as simplified by Shen *et al.* [6]. About 1 g of the biochar samples was weighed into a Falcon® centrifuge tube and 20 mL of 0.5 M $BaCl_2$ was added. The mixture was then agitated on an end to end shaker at 200 rpm for 2 hours and filtered using a 0.45 µm filter. The concentration of exchangeable bases (Na, Mg, K, Ca, Mn, and Fe) in the filtrate was measured using the Analyst 400, PerkinElmer, USA atomic adsorption spectrometry. In addition, the concentration of Al was quantified by the Optima 8300 DV, Perkin Elmer, ICP-OES. The CEC was calculated as the sum of all cations in the biochar sample ($cmol_c kg^{-1}$).

References

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