Assessing the potential of urban soil for carbon sequestration by adding wheat straw pellets or wheat straw biochar

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INTRODUCTION

To mitigate climate change impacts, feasible and economical soil management options in the urban environment cannot be neglected. Increasingly, urban soil has been shown to provide ecosystem services by sequestering C. Biochar and biomass amendments to soil are becoming popular due to multiply functions (manage waste; produce energy; mitigate climate change; improve soil quality). In this context, considering carbon mass balance techniques is important to interpret the functioning of the carbon cycle. This study set up lysimeter field trials to monitor the effect of wheat straw biochar and pellet amendment on the carbon exchange, carbon transportation, and the change of carbon mass in soils. These results will be used to assess the potential benefits of the application of soil amendments on the Helix site in Newcastle where a carbon capture garden will be built.

METHODS

1. Two lysimeters were installed as a part of the National Green Infrastructure Facility in Newcastle University with the addition of wheat straw biochar (BC) or wheat straw pellets (WP), respectively.
2. Carbon fixation by grass, the carbon stock in soil, and carbon loss caused by leaching and carbon dioxide emitted from soil respiration (four soil depth: 10cm, 35cm, 50 cm, 75cm) were observed and measured over 18 months. A calculated mass formula would be: carbon augmentation in soils = (carbon from the amendments + carbon from grass biomass - leaching C loss - C loss from gas emissions). If the obtained value is positive, it means the soil additions have stored carbon over the observation period, which confirms that biochar or biomass has the potential to sequester carbon in soils.

RESULTS

Lysimeter BC; lysimeter amended by wheat straw biochar; Lysimeter WP: Lysimeter amended by wheat straw pellets

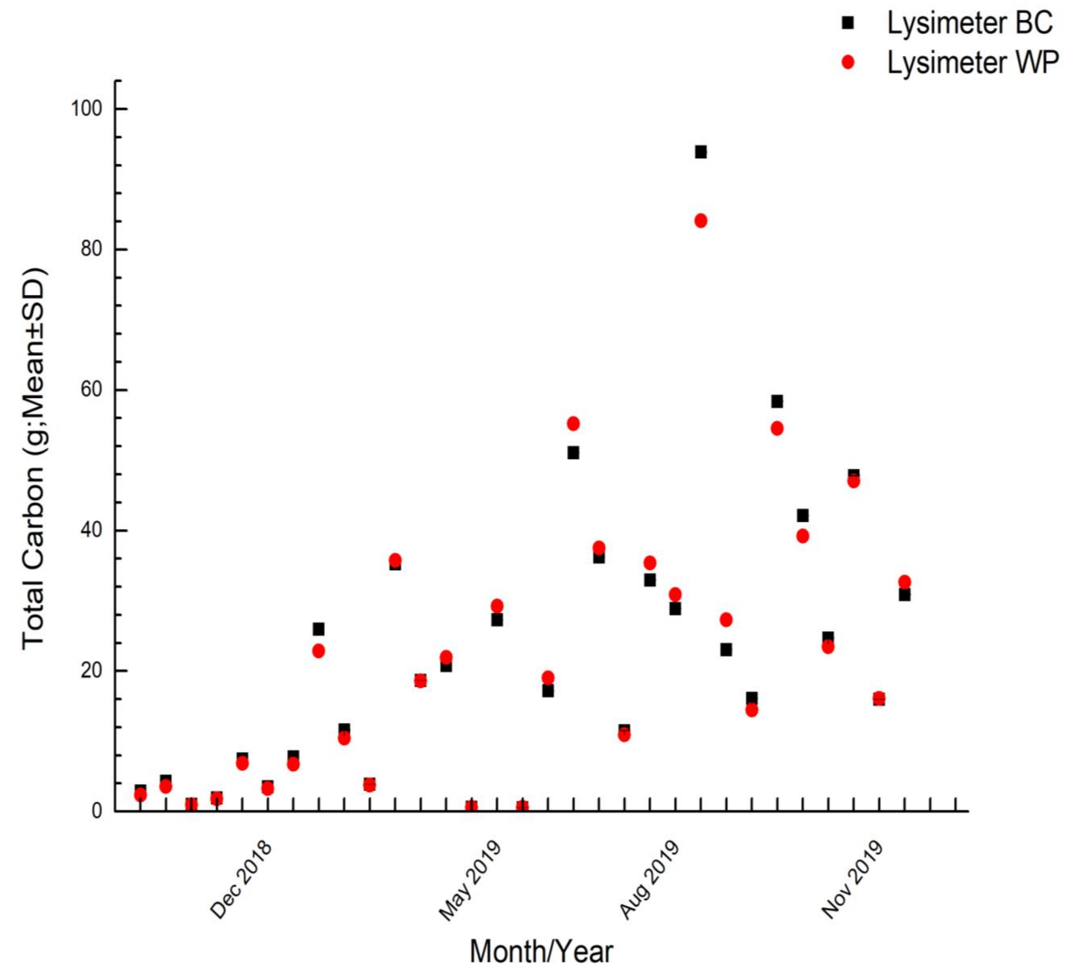

Figure 1. Carbon loss (g; mean ± SD) via leaching for each sample collection date. No significant difference between lysimeters *P>0.05*.

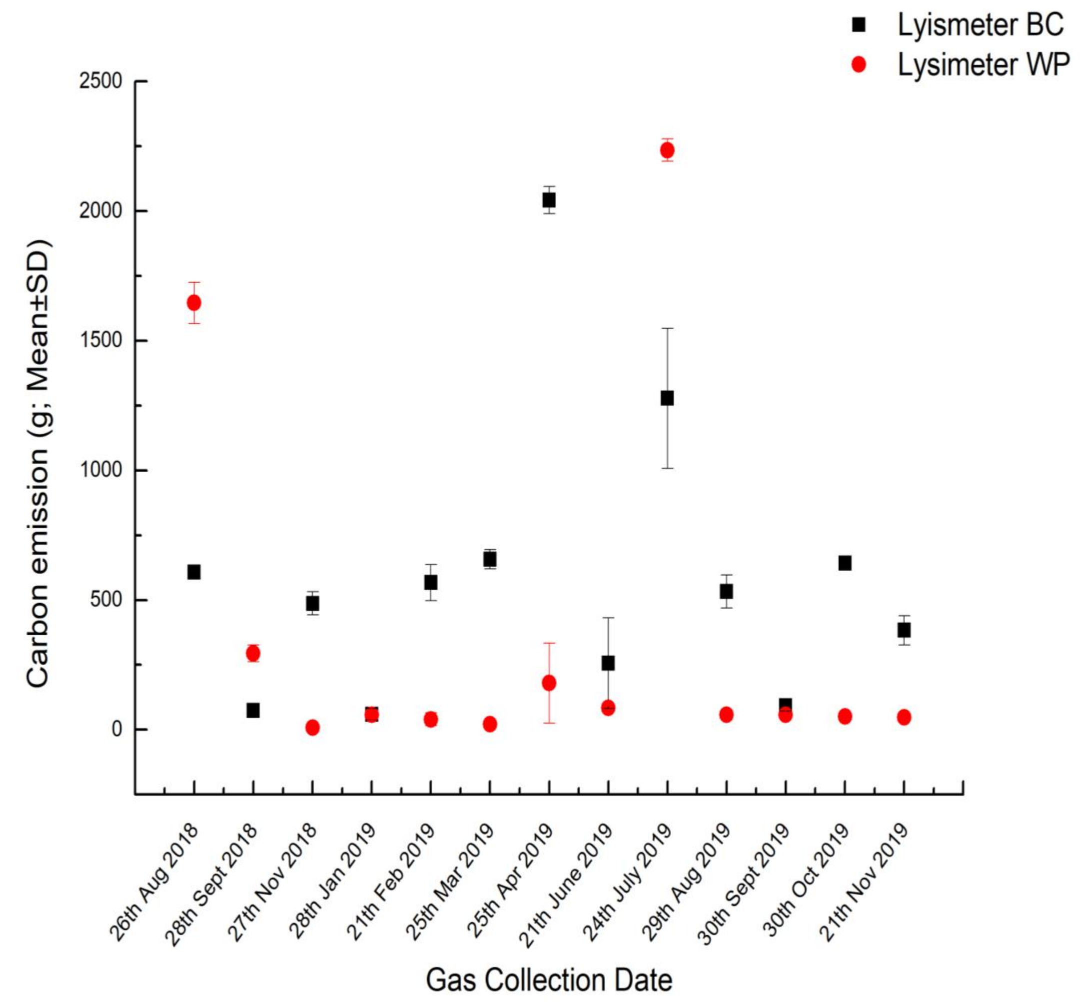

Figure 2. Carbon emissions (g; mean ± SD) as CO_2 from topsoil for each month. No significant difference between lysimeters *P>0.05*.

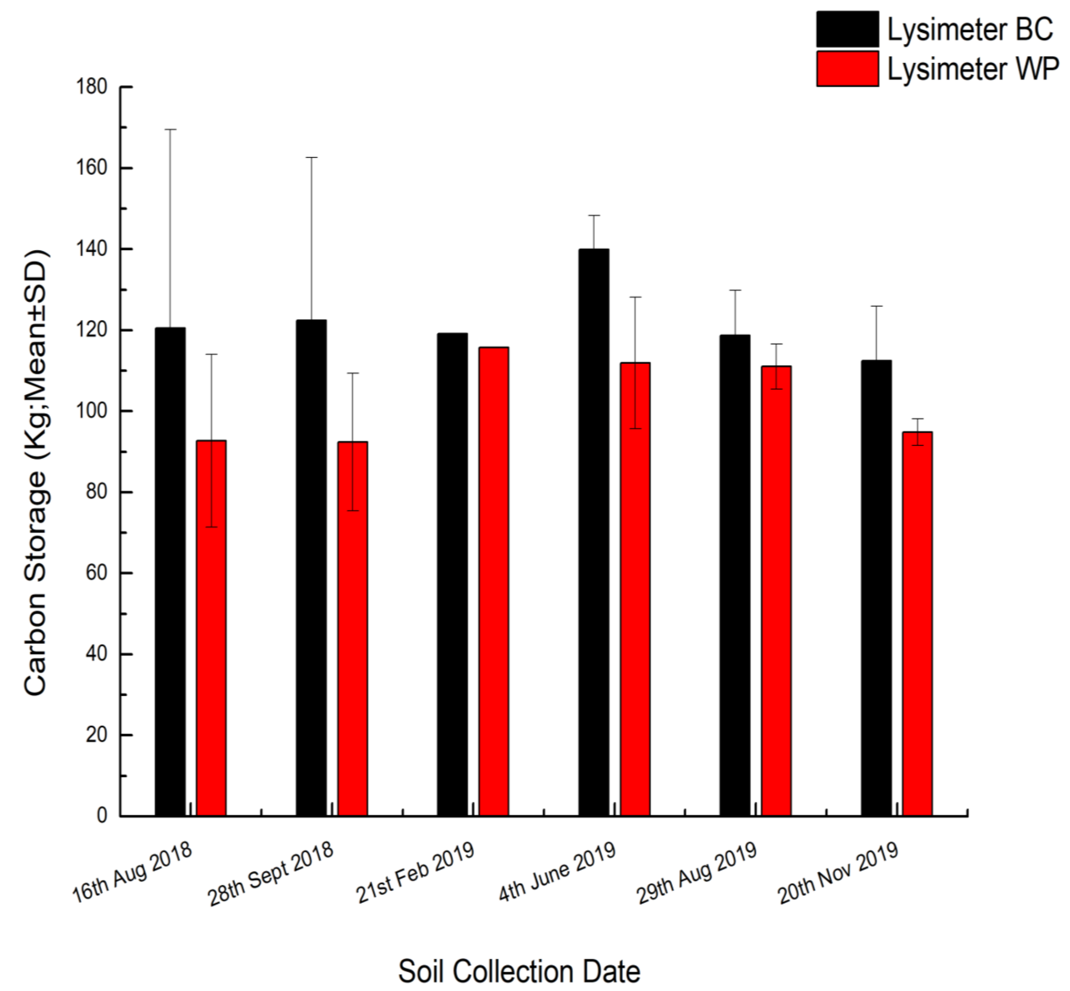

Figure 3. The total soil carbon augmentation in the topsoil (kg; mean ±SD). Significantly higher in the BC amended lysimeter *P<0.01*.

1. As for the leaching of C from two soil systems over 18 months (June 2018-Nov 2019), the concentration of total C in the BC lysimeter (93.31 mg/L) was slightly higher than that from WP lysimeter (92.08 mg/L) on average, but the p-value was 0.60 which means that there was no statistically significant difference between the two lysimeters.

2. Soil respiration was not statistically different as a function of soil depth between the two lysimeters (p>0.05); soil depth affected the CO_2 flux within the BC lysimeter (p<0.001) where carbon flux would decrease with depth, whereas this impact did not exist significantly in lysimeter WP (p=0.187) although the same declining trend was observed with depth. The seasonal influence (background temperature) on carbon flux in the BC lysimeter was statistically apparent (p< 0.01) in the order: spring >summer> autumn> winter. This phenomenon was similar but not statistically significant in WP (p= 0.062).

3. Carbon stored in surface soil was significantly higher for BC than WP (p<0.01).

4. In total, the amount of carbon stored in the BC lysimeter was 16.07± 13.6 kg higher than the carbon mass added after 18 months ; Whereas, lysimeter WP lost 5.17 ±3.41 kg of the carbon added.

DISCUSSIONS /CONCLUSIONS

National Green Infrastructure Facility

1. Environmental temperature and soil profile greatly influenced carbon emission in biochar-amended soils. No significant differences from CO_2-C and leaching C were found in two lysimeters over 18 months. Whereas, carbon content of soils in the two systems is statistically significantly different, and biochar amendment increased top soil C from 7.01% (w/w) to 8.37% (w/w). Therefore, these results demonstrated that the abilities of biochar versus biomass for carbon storage in urban soil differ significantly, and biochar is more suitable for carbon storage.
2. Overall, the green space at the Helix site Newcastle University owns has the potential to store a total of 41.69 tons carbon if the wheat straw biochar (2%;w/w) is incorporated into the surface soil on the 2.5 acres construction sites. The carbon augmentation was found to be stable of the observation period of 1.5 years.