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Py-GC-MS characterisation of fresh and aged biochars produced from green waste, paper mill sludge and chicken manure

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Introduction

A biochar's interaction with a soil is known to be complex as the biochar reacts with organic matter, microbes and minerals within a short period of time after being applied to soil to form an outer organomineral layer [1]. This aging process aids development of the soil structure and increases the capacity of the soil to retain nutrients and recent research has indicated that aged biochars are much more effective in increasing nutrient uptake [2]. The initial composition of the biochar is also important as different biochars placed in the same soil at the same time appear to react at different rates and form different structures. Previous work has been carried out to characterise these structures using a range of techniques [2]. This paper reports the Py-GC-MS results of biochars, prepared by slow pyrolysis of green waste (GW), chicken manure (CM) and paper mill sludge (PMS), in the fresh and aged (applied at a rate of 10 t/ha to a ferrosol soil in NE NSW where sweet corn was grown for 9 months) states at two pyrolysis analysis temperatures; 340°C and 520°C.

Results and Discussions

The data for the pyrolysis of fresh and aged chars at the two pyrolysis analysis temperatures are shown in Figures 1 and 2. The chromatograms are of varying complexity and the products of pyrolysis are difficult to identify, but can be classed, generally, as aliphatic or aromatic. Of the fresh chars, the Py-GC-MS chromatograms of the GW char were found to be the least complex containing mostly aliphatic long chain hydrocarbons as the pyrolysis products. The CM char behaved similarly, but contained more nitrogen containing pyrolysis products indicating a greater nitrogen content of the original char. The PMS char produced the most complex chromatogram containing aromatic pyrolysis products, in addition to the nitrogen containing and aliphatic hydrocarbons. The Py-GC-MS chromatograms of the aged biochars were all found to be more chemically complex than their fresh counterparts. The order of complexity, however, remained the same with the PMS char containing the greatest variety of hydrocarbons from aliphatic to aromatic. The CM char contained significant proportions of the initially observed aliphatic and nitrogen containing long chain hydrocarbons, but also contained aromatic material. The GW char was the most similar to its fresh counterpart, but had also evolved in the soil to produce some aromatic content. A noticeable feature of all the aged biochars was the increase in the proportion of more volatile hydrocarbons observed at the 340°C analysis temperature.

Previous investigations of these biochars have found that the greatest increase in dry biomass yield was achieved by the PMS and least by the GW char. This trend correlates with the increasing chemical complexity.

Conclusions

A correlation between the effectiveness of the biochar and the complexity of the Py-GC-MS chromatogram was observed. The increased complexity in the chromatogram was accompanied by an increase in the aromatic content suggesting that aromaticity is also an important factor in biochar activity.

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[2]Amonette JE, Joseph S (2009) Physical properties of biochar. In 'Biochar for environmental management. Science and technology.' (Eds J Lehmann and S Joseph) pp. 13-323. (Earthscan: London).

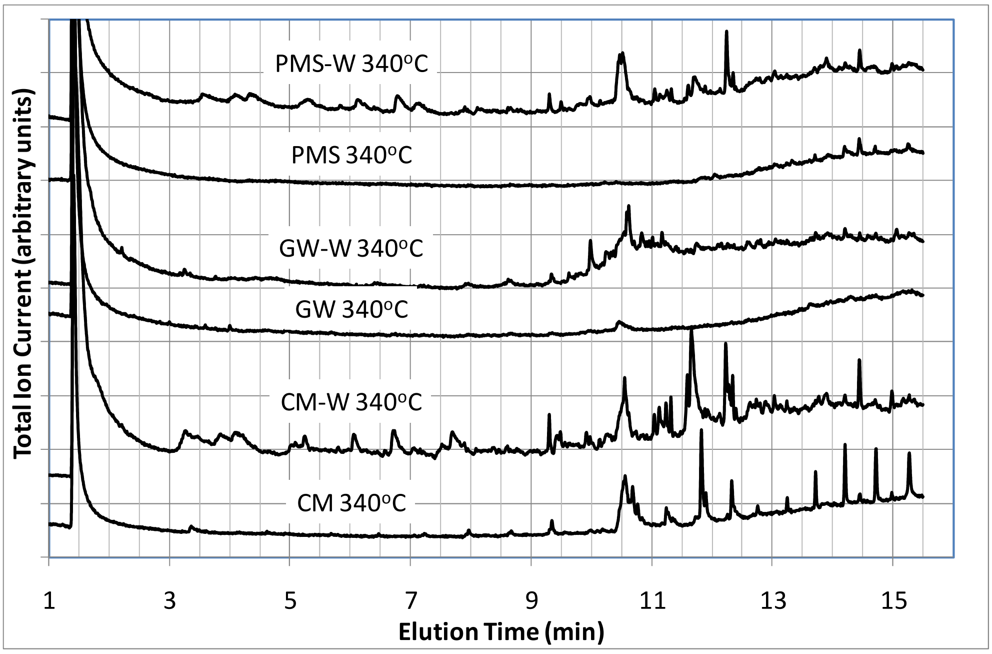

Figure 1. Py-GC-MS data collected for the pyrolysis of biochars at a pyrolysis analysis temperature of 340°C.

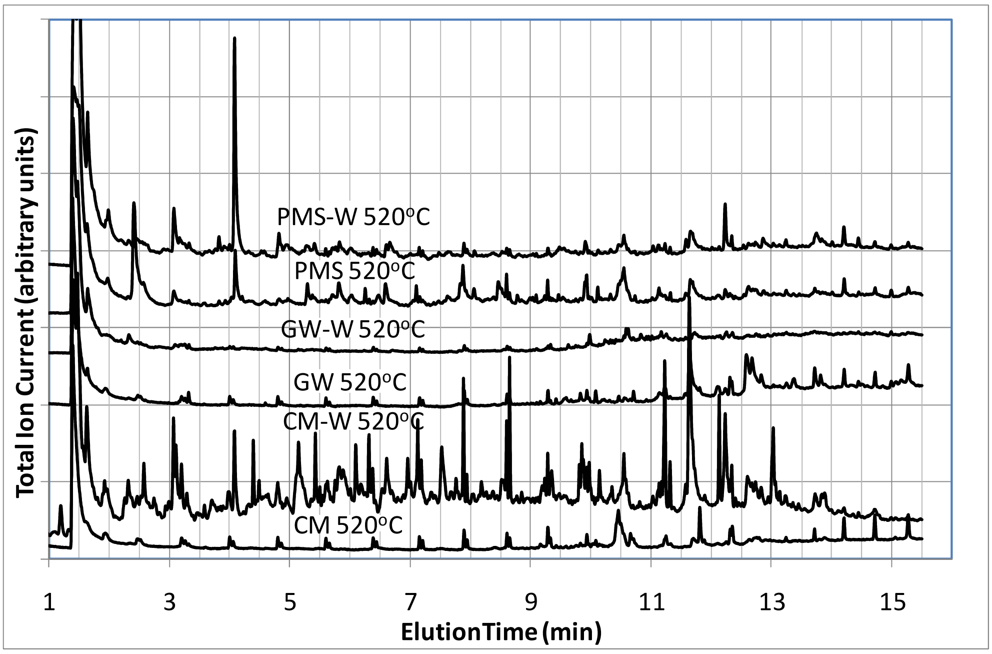

Figure 2. Py-GC-MS data collected for the pyrolysis of biochars at a pyrolysis analysis temperature of 520°C.