Black carbon in urban soils: quantification, distribution and correlation to traffic flow

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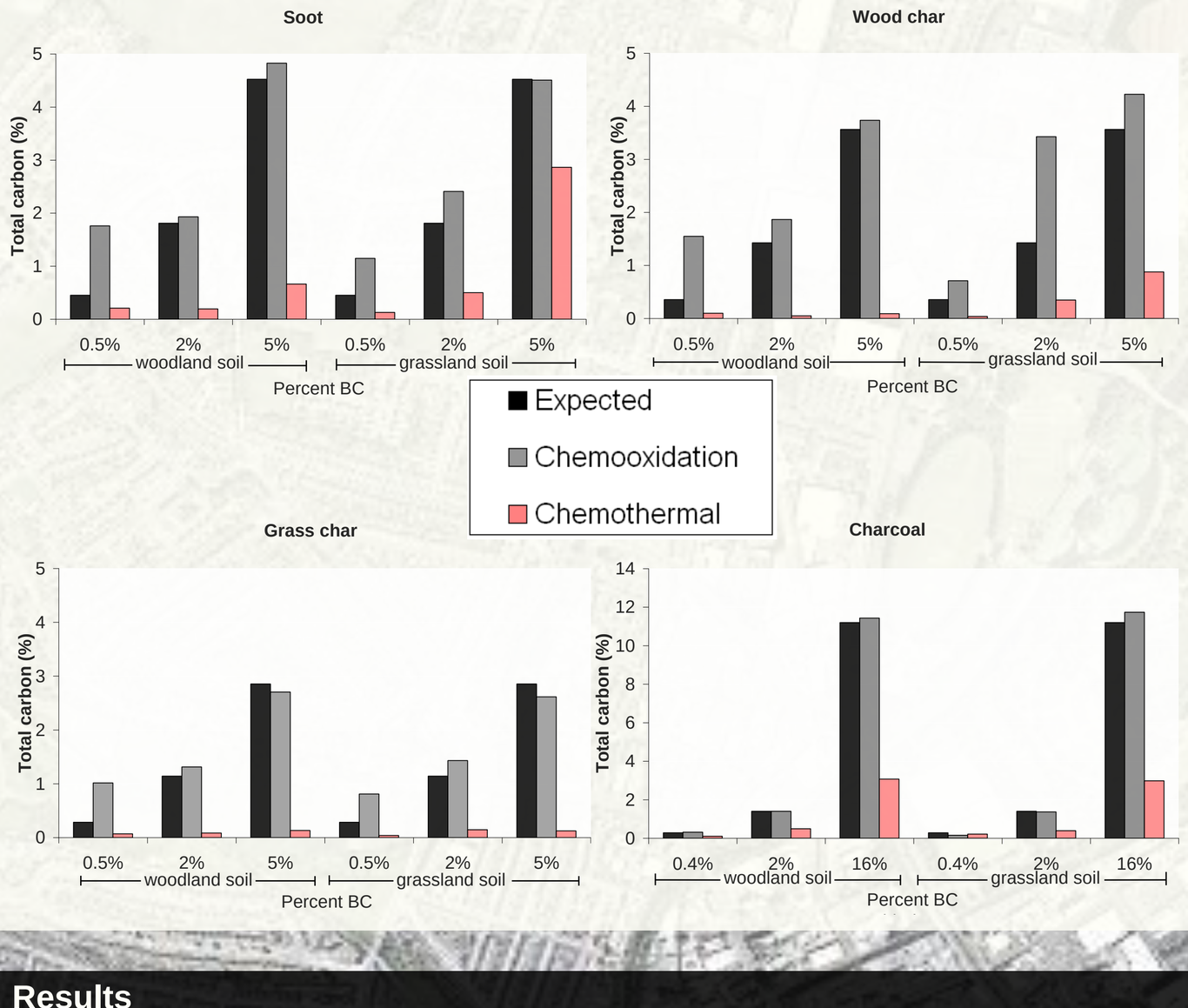
Introduction

The incomplete combustion of biomass and fossil fuels produces a continuum of organic compounds such as char, charcoal and soot, known collectively as black carbon (BC). BC is highly recalcitrant, having a soil residence time often >100 years. It thereby represents a long-term carbon sink, and confers the concurrent benefit of immobilising organic pollutants in the soil. BC has been reported to comprise 5-40% of total carbon in the soils of three UK cities known for their highly industrial past (Rawlins *et al.*, 2008). However, the main sources of BC now entering urban soils are from diesel-fuelled vehicles. The extent of spatial variability of BC concentrations in urban soils, and the role of traffic in this variation has not been investigated.

This research examines the distribution of BC throughout a city: whether its dispersal in soils varies by soil depth, land use type, and proximity to main roads. Methods for BC quantification are also being evaluated to establish an effective protocol. This work will allow researchers to refine urban carbon storage estimations, understand BC dispersal patterns and explain changes in soil organic carbon over time.

Figure 1. Chemooxidation vs. Chemothermal Oxidation



Methods

- Soil samples were taken to 15cm depth from a transect across the grassed central reservation and the western roadside verge of Narborough Road, a main thoroughfare connecting the M1 and Leicester city centre (Fig. 2).
- Two methods of BC detection were tested by adding known amounts of laboratory-produced BC (soot, wood char, grass char and charcoal) to urban woodland and grassland soil, and measuring recovery rates (Fig. 1).
- A chemooxidative (CO) wash method, which removes inorganic carbon and labile (non-black) organic carbon, was compared to the established procedure of chemothermal oxidation (CTO). CTO involves the same wash treatment but is followed by heating to 340°C.
- Soil was analysed for total carbon with a C:N analyser (vario EL cube, Elementar), assuming that any carbon remaining after CO or CTO is BC.
- Chemooxidation, determined to be the more accurate method, was used to quantify BC in the Narborough Road soil samples (Fig. 3).

Results

- The CO wash treatment gave very accurate recovery at BC concentrations ≥ 2% of soil dry weight (117% recovery), but tended to overestimate values of 0.5% BC or less (Fig. 1). The conventional CTO method seriously and systematically underestimated BC, detecting < 25% of the actual BC content.
- Soil collected beside Narborough Road was found to contain over twice as much BC as soil 25m away from the road (Fig. 3).
- The concentration of BC in the central reservation of Narborough Road was 1.75% of soil dry weight, approximately 26% of the total carbon content.

Figure 2. Narborough Road

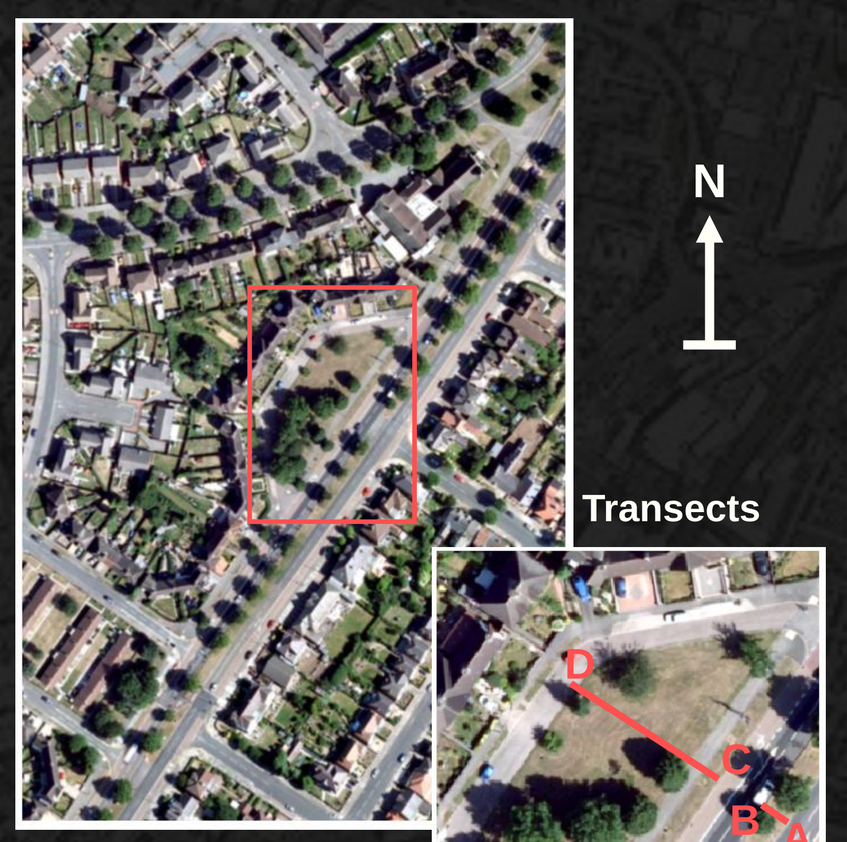
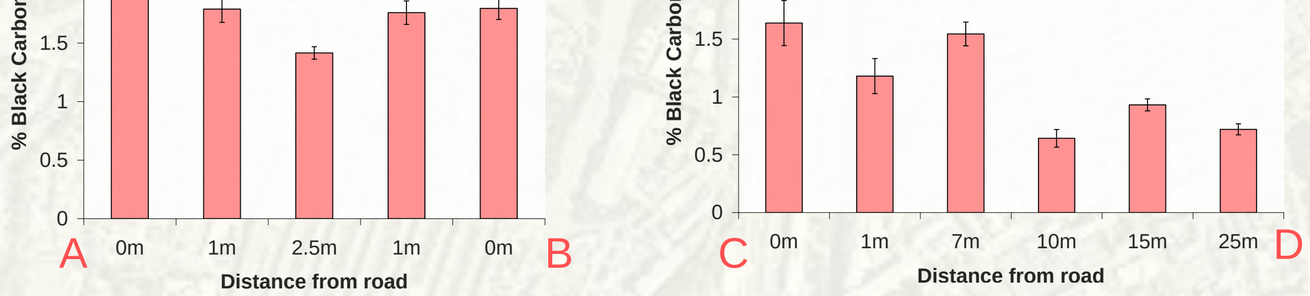


Figure 3. Narborough Road BC Concentrations



Future work

- Repeat transect study at other points along Narborough Road and along other roads in the city of Leicester.
- Analyse these data in combination with Leicester traffic flow information collected by 4M collaborators at Newcastle University.
- Perform CO analysis on soils taken from different urban greenspace types to determine how BC concentrations vary by land use type and proximity to traffic.
- Determine what proportion of BC in Leicester soils is derived from diesel burning, and the proportion resulting from coal burning.

Rawlins B.G. *et al.,* 2008. Methods for estimating types of soil organic carbon and their application to surveys of UK urban areas. *Soil Use and Management*, 24, 47-59.

4M is a consortium of five UK universities, funded by the Engineering and Physical Sciences Research Council under the Sustainable Urban Environments programme (grant reference EP/F007604/1). The university partners are assisted by an advisory panel drawn from UK central and local government, and UK and overseas industry and academia. For further information please see www.4Mfootprint.org.

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