A tale of two cities - why can't we account for large differences in topsoil SOC concentrations in two cities?

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Introduction and objectives

Topsoil (0-15 cm) geochemical surveys of Stoke-on-Trent (n= 737 sites) and Coventry (n=395 sites) were undertaken by the British Geological Survey in 1993 and 2000, respectively. Typical sampling locations were gardens, parks, recreational fields, road verges, schoolyards and various types of made ground. Estimates of topsoil organic carbon (<2mm) were made for each sample based on their loss-on-ignition values and regression equations for a subset of samples analysed for TOC (Rawlins et al.,2008). Black carbon (BC) concentrations were also determined for the same subset of samples. After accounting for the differences due to BC content, there was a substantial difference between the distributions of soil organic carbon (SOC) estimates (see Fig 1 & 2) which cannot be attributed to small climatic differences for the two cities. The aim of our study is to try to explain these large observed differences in SOC.

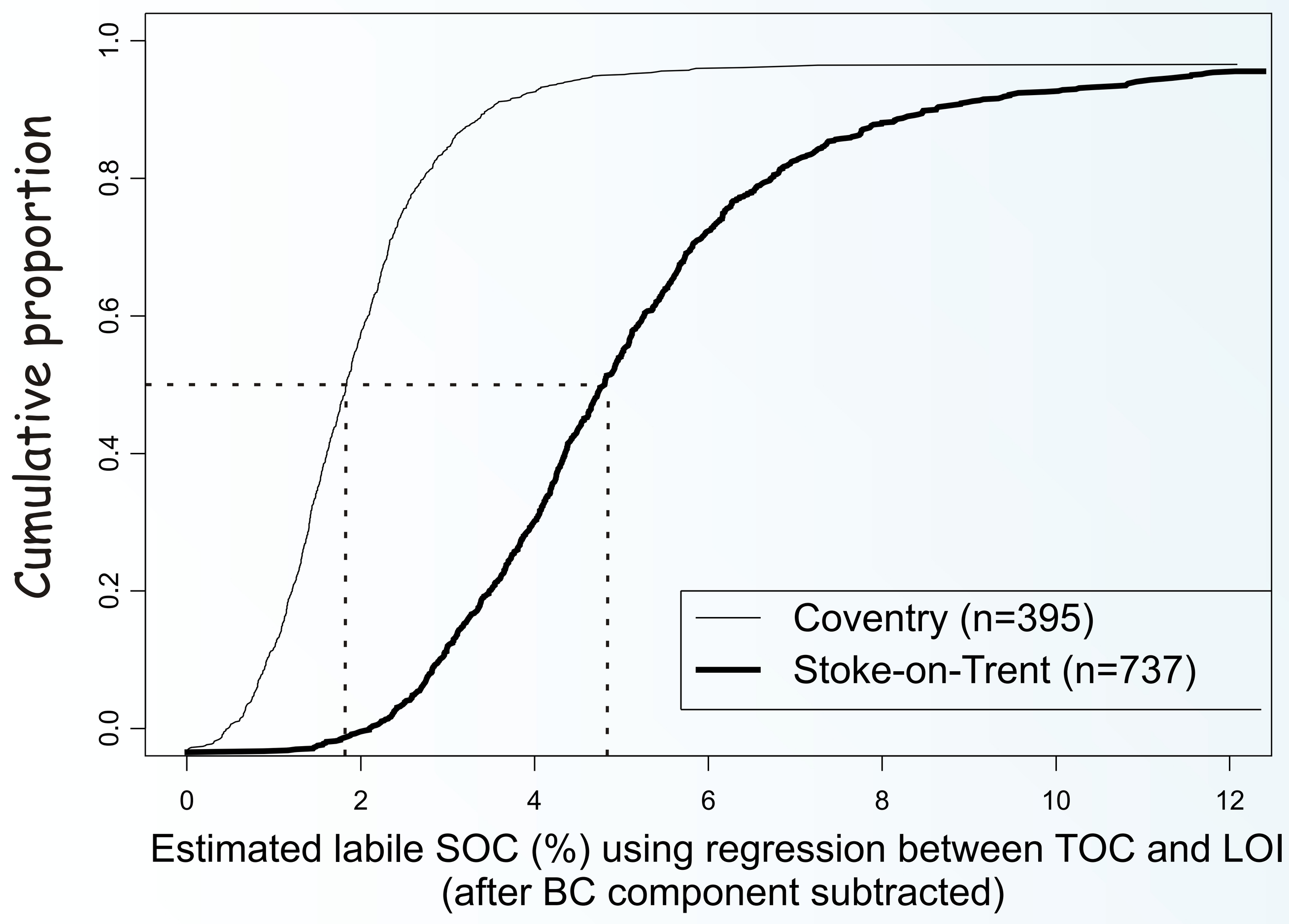

Figure 1 - Cumulative distributions of SOC for the two cities

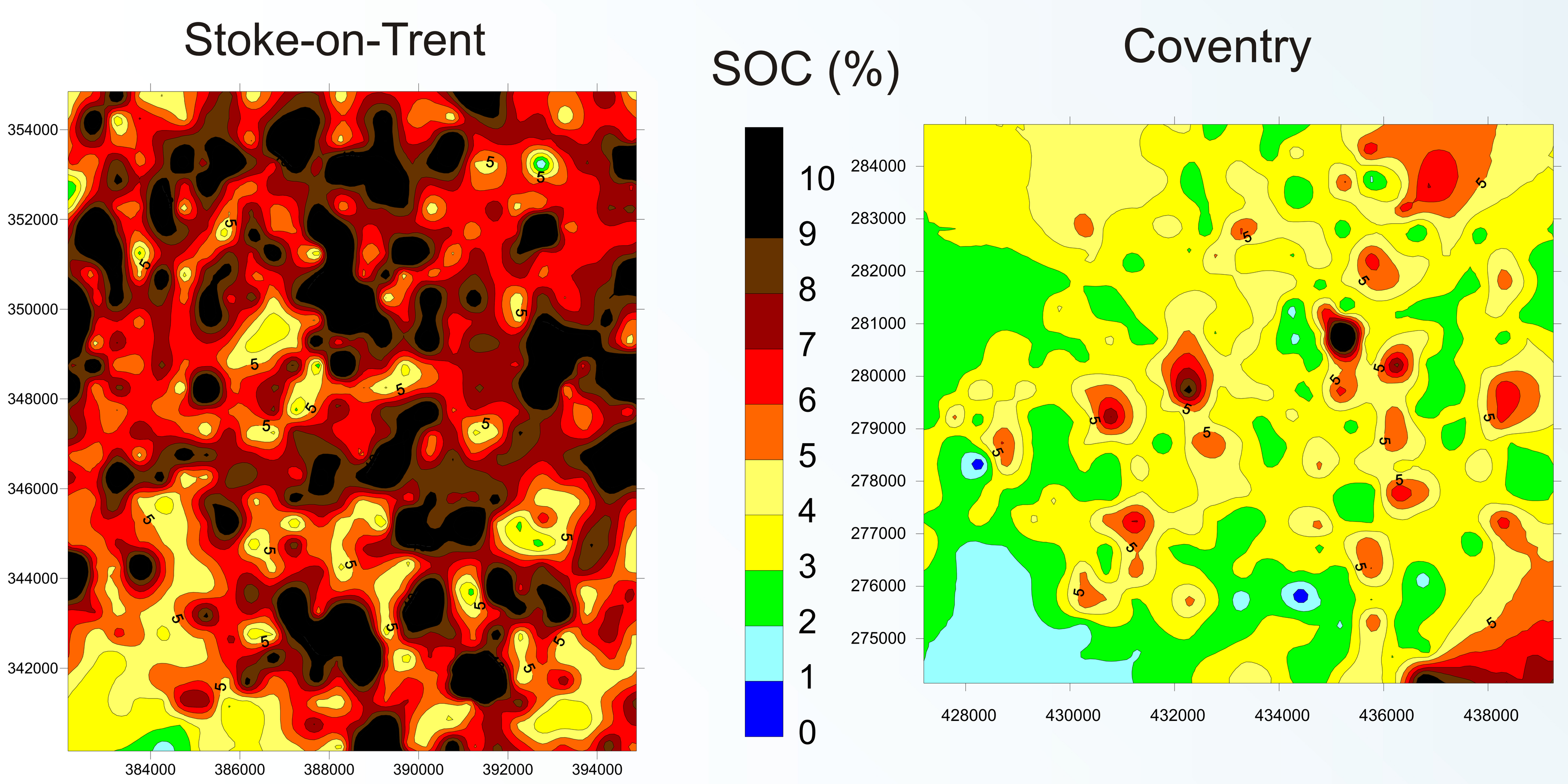

Figure 2 - Interpolated spatial distribution of SOC (%) across Stoke-on-Trent (left) and Coventry (right). Coordinates are metres of the British National Grid

Soil texture

Soil texture could account for the differences in SOC; larger quantities may be sorbed to the surfaces of finely textured soils and their greater propensity for aggregation may also protect this carbon. We have estimated soil texture using soil geochemistry at each site (Rawlins et al., 2009) - see Figure 3.

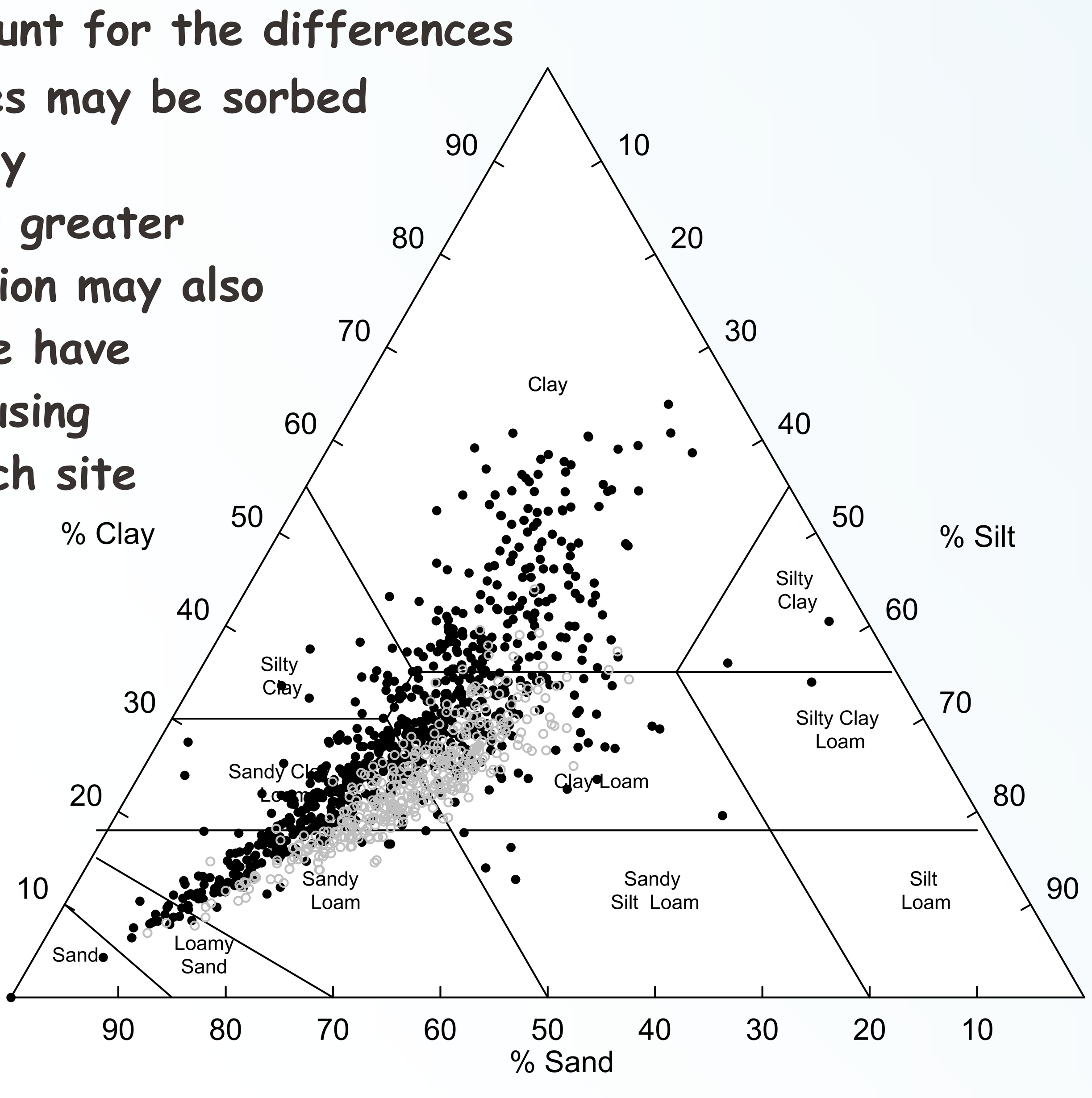

Figure 3 - Topsoil texture estimates for Stoke-on-Trent (black) & Coventry (grey)

Soil and parent material types

The parent materials of the two cities are from different geological periods. Stoke-on-Trent is largely underlain by Carboniferous Coal Measures whilst the parent material in Coventry is dominated by Permo-Triassic mudstone and sandstone. We questioned whether fossil charcoal (e.g. Fusinite) could contribute to the organic carbon pool in the soils of Stoke, but we expect this would have been accounted for by our measurements of black carbon which were subtracted from TOC. Another potentially significant factor was the local occurrence of the organic-rich Wilcocks soil series in the vicinity of Stoke-on-Trent, which has substantially elevated SOC contents (ca. 25%). If such soils occurred within the urban area they could lead to elevated SOC values. As the carbon in such soil would be substantially older, we expect their C:N ratios to be much larger than typical urban soils. We determined total C, total N and calculated C:N ratios for twenty soils from each of the two cities across the full range of SOC contents (see Table 1 below).

	Median		Mean		StDev	
	Stoke	Coventry	Stoke	Coventry	Stoke	Coventry
C (%)	4.49	2.88	5.86	4.18	5.95	3.33
N (%)	0.29	0.23	0.31	0.23	0.18	0.12
C:N ratio	16.37	15.43	17.55	16.46	6.33	4.87

Table 1 - Summary statistics for C, N, & C:N for 20 samples from each city

Modelling carbon inputs

We considered that the SOC concentrations in Stoke-on-Trent (median ca. 5%) were higher than might be expected for typical urban soils. We wanted to establish the quantity of C input required to maintain these levels assuming the carbon inputs and losses are at equilibrium. To do this, we ran the Roth-C model for ten sites across the full range of SOC contents. At these sites we had data for SOC, soil texture, inert organic matter (black carbon). We estimated bulk density using a pedotransfer function.

Conclusions and further work

1. We found that soil texture differed between the two cities - but the magnitude of the difference could not account for the variation in SOC.
2. There does not appear to be any significant difference between C:N ratios; there is no evidence that naturally occurring, SOC-enriched -soils account for the larger observed SOC in Stoke-on-Trent.
3. Annual carbon inputs required to maintain the SOC concentrations between 1.1 and 12.7 % were 0.96 to 5.42 tonnes C $ha^{-1}yr^{-1}$. Three of the sites required more than 5 t ha^{-1} yr^{-1} which we consider to be substantial quantities for urban soils.

At present, we do not have detailed information on land use change (i.e. date since last disturbance) for the soil sampling locations in both cities. We intend to collate this information in the next 3 months. It is well known that Coventry was heavily bombed during WWII and the associated soil disturbance may have led to increased mineralisation and loss of SOC; by contrast only 3 bombs fell on Stoke-on-Trent. Soil disturbance associated with reconstruction after the war may also have contributed to a substantial loss of soil carbon in Coventry.

References:

Rawlins, B. G., Vane, C. H., Kim, A. W., Tye, A. M., Kemp, S. & Bellamy, P. H. 2008. Methods for estimating types of soil organic carbon and their application to surveys of UK urban areas. Soil Use & Man., 24, 47-59.
Rawlins, B. G., Webster, R., Lawley, R., Tye, A. M. & O'Hara, S. O. 2009. Estimating particle-size fractions of soil dominated by silicate minerals from geochemistry. Eur J Soil Sci, 60, 116-126.

Acknowledgements

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