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The Soil-City Interface

Soil organic matter and ecosystem services

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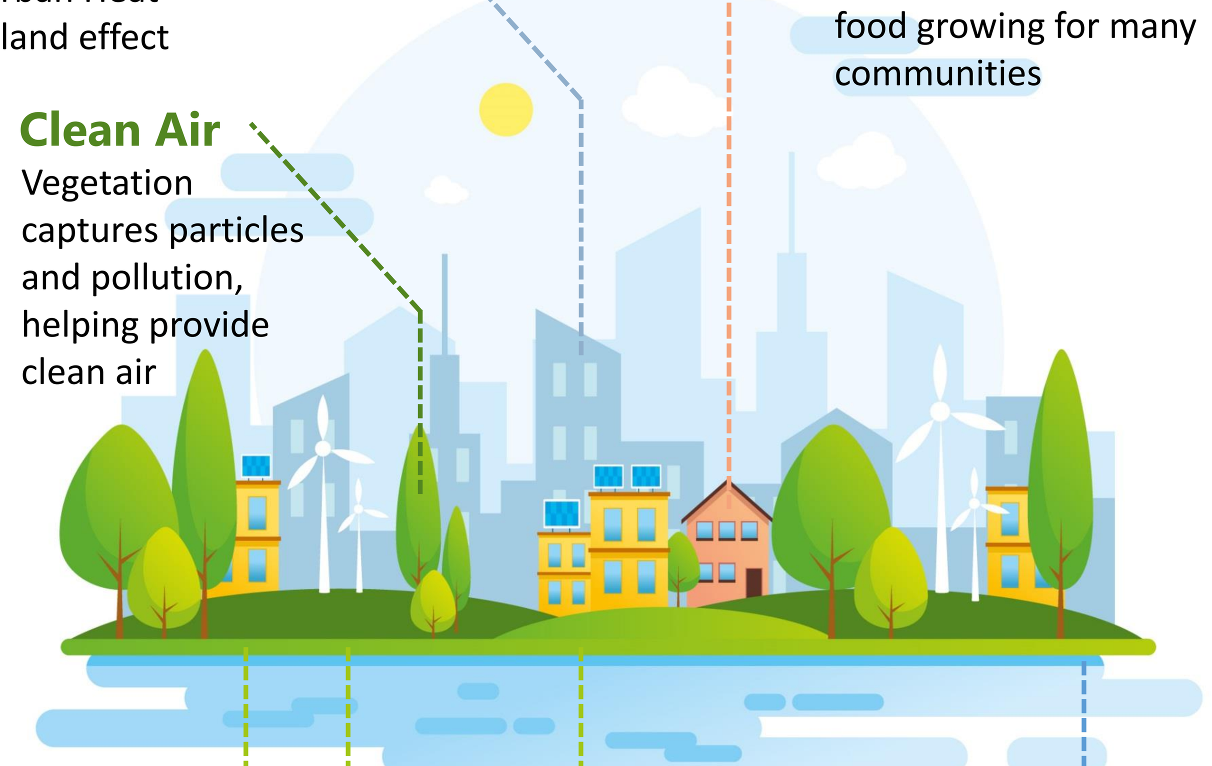
1. Urban soil provides ecosystem services

Local Climate
Vegetation decreases the Urban Heat Island effect

Urban Food
Healthy soil in gardens and allotments supports urban food growing for many communities

Clean Air
Vegetation captures particles and pollution, helping provide clean air



Carbon Storage
Vegetation in greenspaces allows carbon to be sequestered, helping to mitigate climate change.

Biodiversity
Soil and the habitats it provides allow greater biodiversity in cities

Access to Greenspace
Access to green and open space is important for physical and mental health

Flood Mitigation
Greenspaces allow water to infiltrate into the soil, improving water storage and mitigating flooding

2. Urban soil carbon

Soil organic matter plays an important role in **soil function** and improves **soil properties**[1] including:

- soil structure and aggregation
- biodiversity
- carbon storage
- water holding capacity
- cation exchange capacity and nutrient provision

Soil organic matter is measured as **soil organic carbon** (SOC). SOC in cities is important for both **multiple ecosystem services** & **carbon storage**[2]. To date, few studies have considered SOC as a proxy for multiple ecosystem services in cities.

SOC stores in urban soils may have been **underestimated** in national inventories[3] – little data is available on soil carbon storage across the urban area[2].

Greenspaces and gardens make up a large area of cities. However, there is a lack of research on soil under **'sealed' impermeable surfaces** such as roads or pavements. Only two studies have considered the carbon in soil under sealed surfaces[3,4].

How does soil sealing affect soil?

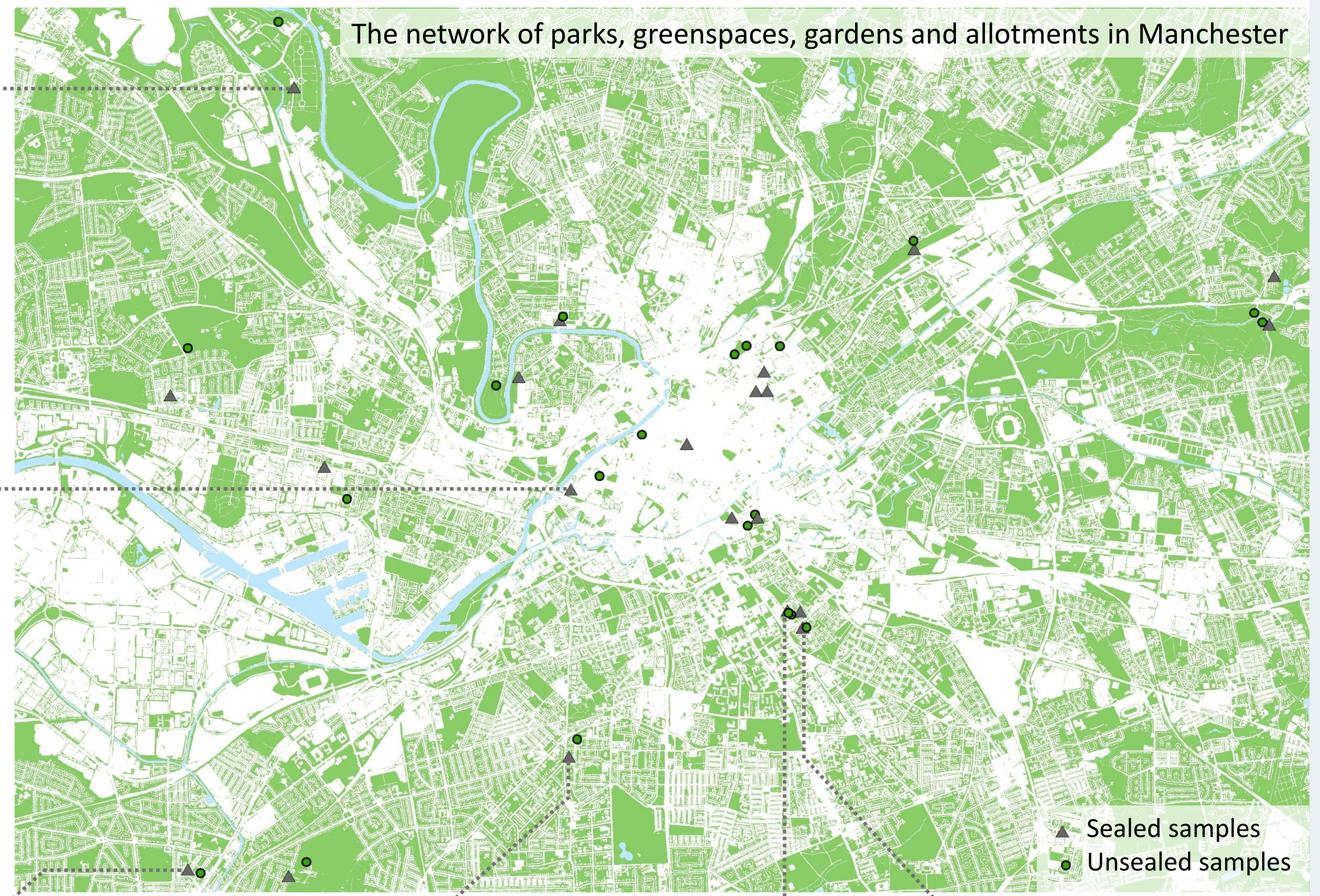
- Reduced water infiltration – change to wetting cycles
- No vegetation - reduced organic matter input
- Topsoil removal during construction
- Coal ash / charcoal included in road construction
- Temperature changes

3. Sampling strategy

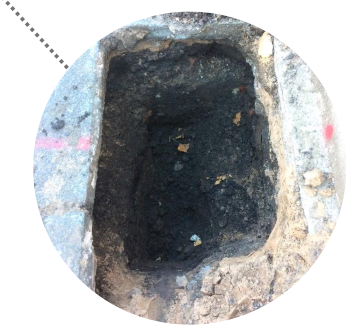
Soils were sampled across Manchester (UK) from greenspaces and from under sealed surfaces (roads and pavements). The aim was to sample a range of urban sealed sites, with nearby greenspaces sampled to provide a comparative dataset.

Cobbles from old roads visible under road surface

Leaking water / utility pipes



Layers of construction material above subsoil layer



Sampling approach

Sealed soils were collected from roadwork excavations from the top 10cm of available soil. In sealed soils, this was the point at which construction materials finished and soil was visible.

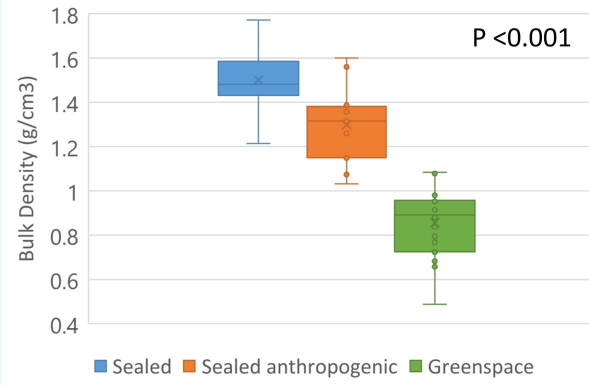
Sealed soil (n 24)
Top 10cm of soil underneath road construction material.
Clay rich subsoil, appears less disturbed by construction activity.

Sealed Anthropogenic soil (n 12)
Top 10cm of soil underneath road construction material.
Clay subsoil mixed with anthropogenic materials such as crushed rock, sand and recycled material.

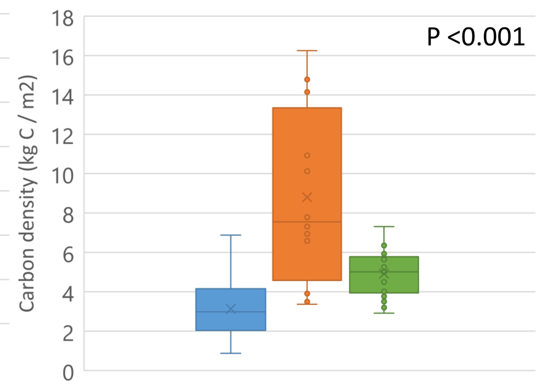
Greenspace soil (n 32)
Top 10cm of topsoil.
Soil collected from parks, road verges and greenspaces.

4. Results

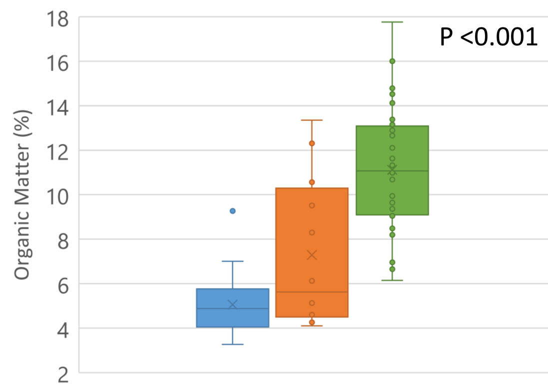
Bulk Density



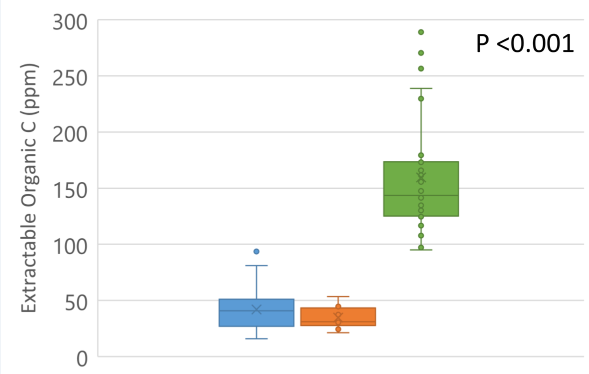
Carbon density



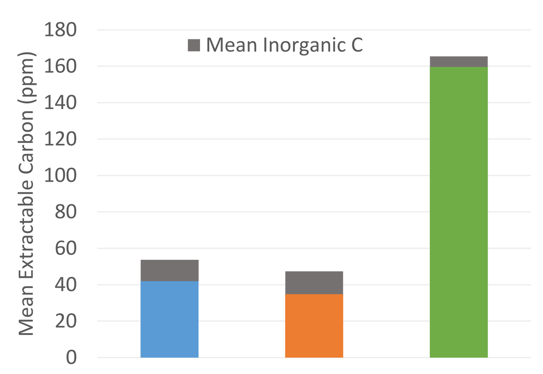
Organic Matter



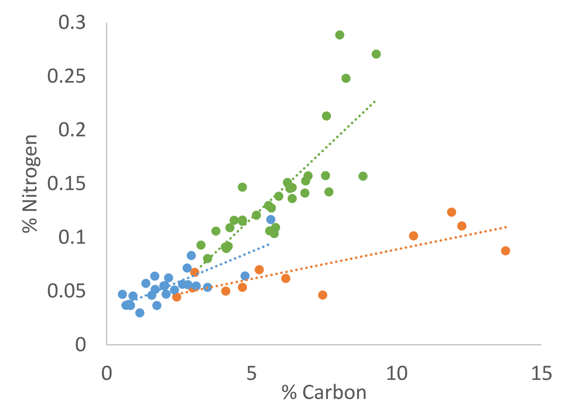
Extractable Organic C



Organic & Inorganic C



CN Ratio



5. Discussion

Carbon density was higher in greenspace soils than sealed soils (4.92 +- 0.4 and 3.14 +- 0.68 kg C/m²) for the top 10cm of soil available. **Sealed anthropogenic soils had much greater carbon density** (8.8 kg C/m² +- 2.84). These were comparable to organic C density found in Leicester (UK) in soil under roads (6.7 kg OC/m², 40-100cm) and pavements (13.5 kg OC/m², 15-100cm)[3].

Both sealed soils had **higher C density than sealed soils in New York** (2.29 kg C/m² at 0-15cm), while New York greenspace soils had a C density of 5.67 kg C/m² at 0-15cm[4].

Sealed anthropogenic soil exhibited high organic matter, though not as high as greenspace soils (7.29% +-2.15 and 11.12% +-0.99 respectively).

The findings suggest that **soil sealing reduces C storage** compared to greenspace soils. However, sealed soils still provide an important store of carbon.

Materials used in road construction may contribute significant amounts of carbon to the soil, thus making **anthropogenic soils an important store of urban soil carbon.**

Sealed anthropogenic soils exhibit **low extractable organic C** despite their high C density and organic matter. This may be due to the **presence of black carbon[5] or charcoal** which may not be extractable. Greenspace soils contain much higher extractable organic C.

The use of charcoal in historic road building, and more recent extensive use of coal fly ash are likely contributions to sealed soil carbon stores.

The CN ratio suggests that carbon in the sealed **anthropogenic soils may not be driven by nitrogen additions, but may be influenced by anthropogenic additions of carbon** in construction material. The greenspace soils show a stronger relationship between carbon and nitrogen.

6. Next steps

Chronosequence study – investigate the effects of sealing over time

- Duration of sealing and its influence on soil carbon
- The effects of sealing over time on nutrients

Modelling study – urban soil carbon

- Use process based soil model, N14CP, in an urban context

References: [1] Bot and Benites (2005) FAO; [2] Lorenz and Lal (2015) Carbon Management 6 35-50; [3] Edmondson et al (2012) Scientific Reports 2 963; [4] Raciti et al (2012) Environmental Pollution 164 248-251; [5] Edmondson et al (2015) Environmental Science and Technology 49 (14) 8339-8346. Infographic: Created by Freepik. Map greenspace data from OS MasterMap Greenspace.