CHEMICAL PROFILING OF SOIL FOR FORENSIC APPLICATION

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INTRODUCTION

- Soil is a complex matrix, composed of a unique combination of mineral (inorganic), organic and molecular level signatures varying on different scales
- To date, the application of soil evidence in criminal cases has been largely under-utilised
- The SoilFit project investigated the potential of chemical profiling of soil, using advanced analytical methods
  - to provide soil forensic intelligence, such as geographical origin
  - to provide evidence

CHEMICAL PROFILING OF SOIL

City comparison study[1]

- Soil was sampled from two urban areas of differing geology, Aberdeen and Milton Keynes
- Samples were taken from 3 common land-use categories (Flowerbeds, Grass lawns, Woodlands) from both cities

XRPD X-Ray Powder Diffraction (XRPD) characterises the mineral component, and provides clues to the underlying geology of a soil.

XRPD results from the city comparison study[1] are presented in Fig 1 and Fig 2. Soils from Aberdeen and Milton Keynes segregated strongly based on the mineralogy.

FTIR Fourier Transform Infrared (FTIR) spectroscopy provides an overall chemical signature of the organic and mineral components of soil.
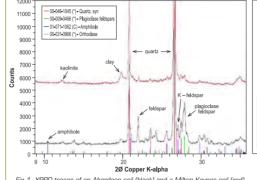
FTIR results from the city comparison study[1] are presented in Fig 3, Fig 4 and Fig 5. Soils from the two cities differentiated from one another predominantly due to mineral regions of the spectra. The only land-use category that could be discriminated from the others was woodland soils from Aberdeen. However, FTIR is well suited for site specific comparisons.

Wax biomarkers, such as n-alkanes and long-chain fatty alcohols, are plant wax compounds that persist in the soil.

Wax biomarker profiles, determined using GC or GCMS, vary for different species of vegetation and can be related to the overlying vegetation and land-use history of a site, see Fig 6.

Study of gardens in the Aberdeen area[2]

The results from a study of soil from gardens in and around Aberdeen showed the potential for wax biomarkers to differentiate between gardens in the same urban area, see Fig 7 and Fig 8.
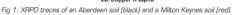

Fig 1. XRPD traces of an Aberdeen soil (black) and a Milton Keynes soil (red).

Fig 2. MDS Ordination plot for the XRPD results from Aberdeen and Milton Keynes soil samples.

Fig 3. Annotated IR spectra of woodland soils from Milton Keynes and Aberdeen.

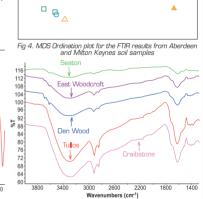Fig 4. MDS Ordination plot for the FTIR results from Aberdeen and Milton Keynes soil samples

Fig 5. IR Spectra of Aberdeen woodland soils.
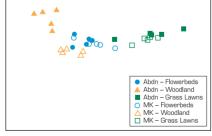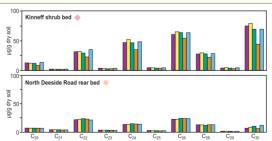

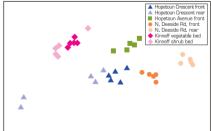Fig 6. MDS ordination plot for the alcohol results rom Aberdeen and Milton Keynes soil samples.

Fig 7. Long-chain fatty alcohol (C_{20}-C_{30}) concentrations from planting beds in two domestic garden sites in the Aberdeen area (five replicate soil samples).

Fig 8. MDS ordination plots of soil long-chain fatty alcohol profiles of domestic garden sites in the Aberdeen area.

OUTCOMES

- Knowledge of the circumstances in which each chemical profiling method is most appropriate and the complementarities of inorganic and organic methods offers powerful potential in increasing the application of soil analysis for police investigation
- The combination of results from each of the profiling methods results in a range of attributes for a soil which increases both investigative and evaluative value

References:
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2. Mayes, R.W.; Macdonald, L.M.; Ross, J.; Dawson, L.A. In: Criminal and Environmental Soil Forensics, (eds, K. Ritz, L.A. Dawson and D.R. Miller), Springer (2009) Chapter 29 pp 463-476.

The Scottish Government

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