Forensics and pollutants (plasticisers and microplastics)

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Forensic soil science is the application of soil science to the law (A Guide to Forensic Geology). It relates to both civil and criminal law, helping investigate and provide evidence to a broad range of contexts including homicides, rapes, fly tipping, wildlife forensics, illegal trading, food, drink and art provenance, garden adulteration, contamination, plastics, metal disposal and characterisation of archaeological frauds. Soil forensic science links environmental science, soils, ecology, botany, eDNA, and the law, and delivers intelligence and evidence to the criminal justice system.

State of the art methods have been developed in the discipline of soil science and tested and applied successfully to legal situations across the world (ENFSI APST). Soil, water, dust, air, food, alcohol, honey and water have all been analysed and characterised to the highest quality standard, used in civilian and criminal courts across the world. Using a wide range of methods, questioned samples from fields, vehicles, tools and selected objects can be compared with known reference samples to ascertain likely origin and levels, and compared wider with samples in the Scottish soils archive and related to data held within the Scottish soils database which has been created from long term Scottish Government research funding.

Ongoing research in soil science is developing new and improved quantitative methods that can be applied to increasingly smaller and older samples, allowing the approach to be used in cold cases in an increasing number of cases.

- Donnelly L., Pirrie D., Harrison M., Ruffell A., Dawson L. (2021) *A Guide to Forensic Geology*. London: Geological Society.
- ENFSI. (2019) *Best Practice Manual for the Forensic Comparison of Soil Traces: ENFSI-BPM-APS-02*. https://enfsi.eu/wp-content/uploads/2017/06/ENFSI_BPM_APST_Soil_Examination-vs1.0.pdf
- Ramage S.J.F.F., Pagaling E., Haghi R.K., Dawson L.A., Yates K., Prabhu R., Hillier S., Devalla S. Rapid extraction of high- and low-density microplastics from soil using high-gradient magnetic separation. Science of the Total Environment. 2022; 831, 154912. DOI: https://doi.org/10.1016/j.scitotenv.2022.154912

With impacts of climate change, there is an increasing need to recycle organic waste materials. However, these can also contain potentially toxic constituents such as organic chemicals, plastics, metals and pathogens, and therefore application of organic materials to land has the potential to increase levels of contaminants in soils and cause harm to the environment and affect soil biota, particularly in agricultural soils).

Analytical techniques can measure physical (e.g., HGMS for microplastics), chemical, and biological contaminants, across long-term and spatial scales, and can help deduce contaminant uptake pathways and track resistance genes in plants treated with organic fertilisers.

The change of contaminants in agricultural soils amended by different organic wastes (sewage sludge, compost and manure) was studied and target contaminants, included microplastics, chemicals (e.g., diethylhexyl phthalate (DEHP), a widely used plasticiser in plastic products) and antibiotic resistance genes (ARGs). Results showed that predicted environmental concentration (PEC) of (DEHP) were in good agreement with measured DEHP concentrations in treated soils were in the order: Sludge > Compost > Manure > Conventional. The organic wastes introduced the chemical and microplastics, which increased and accumulated the contaminants in the treated soils.

With multiple applications of organic fertilisers, there were higher ARGs and microplastics in the soil in comparison to the conventional inorganic fertiliser (NPK). Analytical chemical methods have allowed physical, chemical and molecular soil contaminants to be measured, quantified and compared. Ongoing research will further elucidate these processes for safer application of organic materials to land for health. In addition, research has created spatial information on the distribution of these chemical, biological and physical contaminants. A map of the distribution of these contaminants in Scottish soils is currently being created providing a spatial context.