Biomagnetic monitoring as an urban air quality assessment method

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Background

High-levels of urban particulate pollution are known to affect human health. European legislature states that the levels of particulate matter, so called PM_{10} (particles < 10 μm in size), should not exceed 50 $\mu g/m^3$ on more than 35 days per year in a given city – unless their origin can be shown to be natural, e.g., volcanic ash. To try to meet these European requirements and to minimize high-levels of PM_{10}, it is important to understand the origin of PM_{10}, its spatial distribution and transport mechanisms. However, current air quality networks obtain poor spatial monitoring resolution due to high investment and maintenance costs. Especially in heterogeneous urban environments, spatial monitoring resolution is generally too limited.

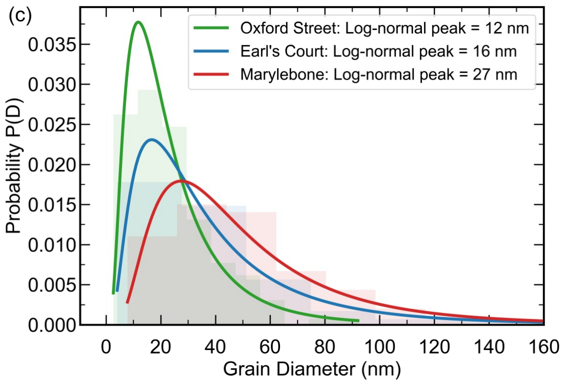

Figure 1. Characterization of grain-size distributions of particulate matter (mostly iron oxides) from various localities in London. From Muxworthy et al. (2022).

One approach to resolving this is bio-monitoring, in particular biomagnetic monitoring. Biomagnetic monitoring is the use of the natural environment, i.e., leaves, to act as PM_{10} collectors, followed by rapid magnetic analysis of these samples. Recent studies by us (e.g., Muxworthy et al., 2022) have shown that very fine iron-oxide particulate matter (< 30 nm in size, Fig. 1), is likely more abundant than previously thought. This is important, as toxicity increases with surface to volume ratio. Identifying very fine particles is challenging as electron microscopy analysis, required to directly determine grain-size distributions at this scale, is time consuming. Another way to determine the grain-size is through magnetic measurements. Magnetic measurements allow for the rapid identification and quantification of fine iron-oxide particles, i.e., < 30 nm, in bulk samples, as such grain-sizes display a strong temperature dependency in their magnetic behaviour.

Hofman et al. (2017) evaluated biomagnetic monitoring of leaf-deposited particles for both air quality monitoring and modelling purposes, on both spatial and temporal resolutions, nevertheless there are still uncertainties in the relationship between the PM_{10} signal captured and permanent monitoring stations and the PM_{10} collected via bio-monitoring. This research project aims to address this gap by evaluating the magnetisable composition of urban atmospheric particles in more detail, its potential for source attribution in urban areas, and the health-relevancy of biomagnetic properties. While the magnetic mineralogy, grain size and concentration will reflect PM source-contributions, associations with heavy metals and/or elemental carbon might emphasize biomagnetic monitoring as a novel health-related PM proxy.

Student Profile: This project is a combined (urban) field and laboratory project and would suit a candidate with an interest environmental science. Candidates should have a good degree in any area of science. Good laboratory skills also desirable, as are the ability to communicate.

References

Hofman, J., Maher, B.A., Muxworthy, A.R., Wuyts, K., Castanheiro, A. & Samson, R., 2017. Biomagnetic Monitoring of Atmospheric Pollution: A Review of Magnetic Signatures from Biological Sensors, Environ. Sci. Tech., 51, *6648-6664, doi:10.1021/acs.est.7b00832.*

Muxworthy, A.R., Lam, C., Green, D., Cowan, A., Maher, B.A. & Gonet, T., 2022. Magnetic characterisation of London's airborne nanoparticulate matter, Atmos. Environ., 287, 119292, doi:j.atmosenv.2022.119292.

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