Oxidative potential of particulate matter in a major urban environment

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Keywords: Particulate matter, oxidative potential, lung, toxicity
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Oxidative potential (OP) is a novel metric that reflects one aspect of the toxicity of ambient particulate matter (Kelly, 2003). By augmenting measurements of the physical and chemical characteristics or particulate matter with this metric, we hope to gain a greater understanding of which components are driving its health effects and which emissions sources require most urgent remedial action. The assimilation of a unique long-term dataset of two indicators of OP across a large urban area allowed us to relate variations in toxicity with meteorological conditions and emission sources.

A database of particulate matter OP from 16 monitoring sites across London over the period 2000 to 2006 was constructed. The oxidative burden associated with collected PM was assessed by measuring the oxidative depletion of antioxidants within a synthetic human respiratory tract lining fluid (RTLF) model (Ayres et al, 2008). This method reports two metrics of oxidative activity; glutathione oxidation ('OP^{GSH}') and ascorbate oxidation ('OP^{AA}'). A aggregation method was used to produce an uninterrupted 'London background' OP time series with weekly resolution utilising results from the six available urban background monitoring sites. Spearman's rank correlation coefficients were produced to show relationships between weekly mean background OP^{AA} and OP^{GSH} per unit mass and per unit volume and various pollutant and meteorological explanatory variables.

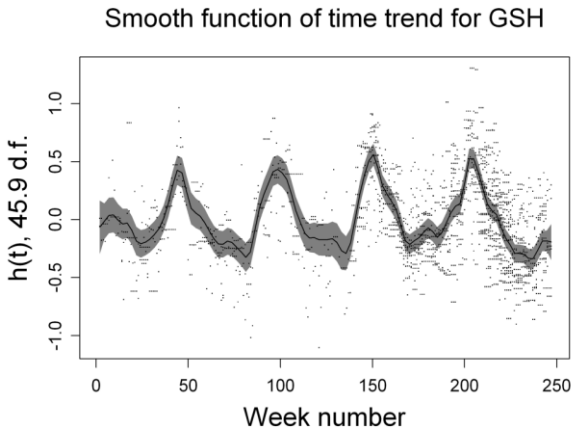

Figure 1. Plot of time trend for GSH OP. The shaded regions and points display pointwise standard errors (including uncertainty about the overall mean) and partial residuals, respectively.

OP^{GSH} exhibited behavior typical of a primary urban pollutant, with peaks in activity coinciding with the lowest mean incoming solar radiation rates (r_s=-0.68) and troughs during the summer months. The correspondingly close relationship between OP^{GSH} and NO_X (r_s=0.46) was an indication that both pollutants are strongly influenced by dispersion rates of local vehicle emissions. There was no correlation between London background PM_{10} and OP^{GSH} (r_s=-0.06), indicating that PM_{10} composition is more important than PM_{10} mass in relation to oxidative activity. There was evidence of peaks in OP^{AA} concentrations during large secondary particulate episodes and the correlation factor for OP^{AA} and rural PM_{10} was higher than any other metric (r_s=0.29). This suggested that regional-scale sources including secondary particulate mass have a greater role in determining OP^{AA} activity. No clear overall trend was apparent in OP^{AA} over the seven year period, but there was evidence of an increasing trend in peak winter time OP^{GSH}.

As far as we are aware this is the first long time series of OP measurements across an urban area. The two OP metrics demonstrated contrasting characteristics and relationships with other pollutants and meteorology. The OP^{GSH} metric provided evidence that each unit of PM_{10} mass has greater oxidative activity during the autumn and winter months than during the summer. The OP^{AA} metric showed a more complex variation but suggested that particle activity may increase during secondary episodes. Neither metric was correlated with particulate mass. This study demonstrated a strong link between primary traffic related pollutants and particle oxidative toxicity.

This work was supported by Heath Effects Institute (USA) and the Medical Research Council (UK).

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