THE METAL CONTENT OF AIRBORNE PARTICLES: APPLICATION TO EPIDEMIOLOGICAL RESEARCH

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AIRNET
A Thematic Network on Air Pollution and Health

NERAM
Network for Environmental Risk Assessment and Management

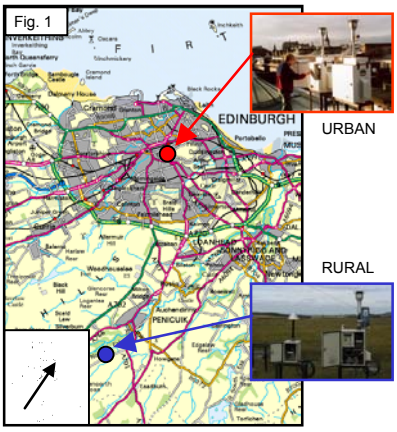
Introduction

- This poster describes the first long-term study in the UK of the quantitative relationship between elevated respiratory & cardiovascular mortality and morbidity rates and the variance in daily metal composition of PM_{10} in urban background air.
- **Research question addressed:** Do observed and/or modelled variations in daily metal concentrations explain additional variance in health outcomes compared to PM_{10} mass concentration alone?

Interpretation of atmospheric science aspects of these data are presented separately

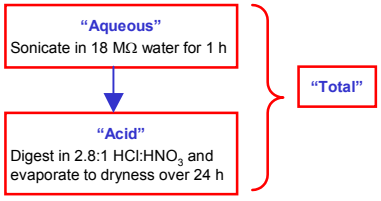
Sample collection

Daily PM_{10}, $PM_{2.5}$, and Black Smoke samples collected for 1 year at an urban background and rural location (Fig 1.)



Metal Analyses

Analysis for Fe, Cu, Ni, V, Zn, Mn, Cd, Cr, As, Ti and Pb by ICP-MS in two sequential extractions of each sample



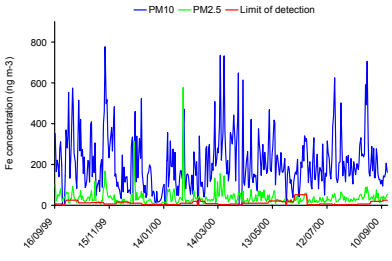


Fig 2 Example time series of daily Fe concentrations 1999-2000

Experimental design

1999-2000: Measure metal concentrations in PM_{10}, $PM_{2.5}$, BS

↓

Poisson regression analyses of 1999-2000 PM_{10}, $PM_{2.5}$, BS & [metal]

↓

Compute & categorise air mass trajectories 1999-2000
For each trajectory category: compute [metal] per particle mass enrichment factors (EF)

↓

Compute trajectories 1992-2000
Multiply EF & observed PM_{10}, BS to estimate [metal] time series

(Also alternative estimate of [metal] time series using multiple regression)

↓

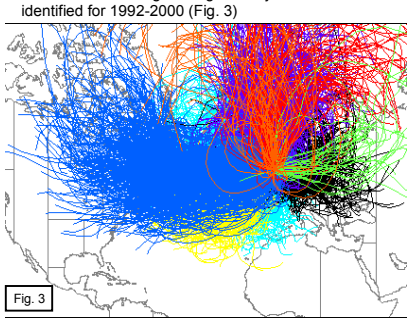
Poisson regression analyses of 1992-2000 PM_{10}, $PM_{2.5}$, BS & [metal]

↓

Do analyses using metrics of metal exposure explain more of the variance in health outcome than PM_{10} metrics?

Influence of air-mass back-trajectory on metal content

- Daily 5-day air-mass back trajectories were calculated and clustered hierarchically using Euclidian squared distance and average linkage. 8 major clusters were identified for 1992-2000 (Fig. 3)



- PM_{10} and $PM_{2.5}$ mass concentrations in air masses from east/central Europe, or centred on the UK were, respectively, 40-40 % or ~25 % higher compared with air masses from the N, W or SW.
- Water soluble metal concentrations of UK and central Europe air masses were up to double those from the W, SW and N
- Metal enrichment factor (ng μg^{-1}) differed significantly between air-mass back-trajectory cluster for most metals (Table 1, Kruskal-Wallis P values).

TABLE 1

	Aqueous	Total
Fe	**0.012**	**<0.001**
Cu	**0.014**	**<0.001**
Ni	**<0.001**	0.31
V	**<0.001**	**<0.001**
Zn	0.10	0.26

Retrospective extrapolation of [metal] time series

- Metal enrichment factors showed large variation within trajectory clusters, hence cluster analysis did not provide very precise estimates for retrospective extrapolation.
- Therefore we also used forward stepwise multiple regression to predict EF from combination of trajectory co-ordinates and local meteorological & co-pollutant observations:

Metal	Trajectory cluster	Regression A	Regression B
Fe	0.07	0.02	0.14
Cu	0.18	0.07	0.49
Ni	0.05	0.10	0.24
V	0.19	0.23	0.39
Zn	0.09	0.07	0.25

- **Table 2** R^2 indicating proportion of variance in EF explained by prediction methods involving trajectory clusters; multiple regression using trajectory co-ordinates (A); and coordinates plus local meteorological and co-pollutant variables (B). n~365.

Epidemiological analyses

- Generalised additive Poisson regression models were used for the time series analyses.
- To reduce multiple testing, subset of 60 'primary' analyses defined: cardiovascular admissions, respiratory deaths and all-cause deaths in subjects aged > 65 in relation to Fe, Cu, Ni, V, Zn in aqueous and total (water plus acid) filter extracts of PM_{10}

Epidemiological results

- We found a significant association between cardiovascular admissions and total PM_{10} (95% confidence limits of +1,+6 (P<0.01) for percent changes in relative risk associated with a 10 $\mu g\ m^{-3}$ range of total PM_{10}, consistent with previous analyses).
- Similar associations were noted for some of the metal fractions using both extrapolation techniques. However, further multiple Poisson regressions showed that metal effects were no longer significant after adjusting for total PM_{10}.

Conclusions

- Using an objective statistical analysis of air mass back trajectories **we did not find that extrapolated concentrations of Fe, Ni, V, Cu, or Zn explained more of the variance in 3 primary health outcomes than PM_{10} mass concentration alone**.
- Further analyses using multiple regression techniques improved the precision of our exposure estimates but still did not show evidence of stronger effects on health from specific metal fractions than from total PM_{10}.
- At present these data do not provide evidence justifying separate regulation of metal constituents of urban PM_{10}.

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