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Source apportionment of $PM_{2.5}$ composition at five sites in the Netherlands

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Presented at the workshop "The Use of Receptor Models in the Source Apportionment of Air Pollutants", Ispra, Italy, 4 & 5 November 2010

ECN-O--10-035 November 2010

National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

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Introduction

The Netherlands is considered one of the hotspot areas in Europe with high concentrations of particulate matter (PM) and will probably not be able to meet all standards for $PM_{2.5}$ in time with current legislation. The Netherlands has to adapt its policies and update monitoring, emission inventory and models regarding PM. To improve our understanding of the composition, distribution and origin of particulate matter in the ambient air a new project called the Netherlands Research Program on Particulate Matter (BOP) was started. We have used the combined $PM_{2.5}$ measurements from this project in combination with Positive Matrix Factorization (EPA-PMF 3.0) to identify and quantify the most relevant source contributions and their spatial variability to $PM_{2.5}$ in the Netherlands.

Measurement data

- Measurement campaign (August 2007 to August 2008)
- Five sites, one kerbside location, one urban background location and three rural locations (Figure 1).

Figuur 1: Location and characteristics of the sampling sites.

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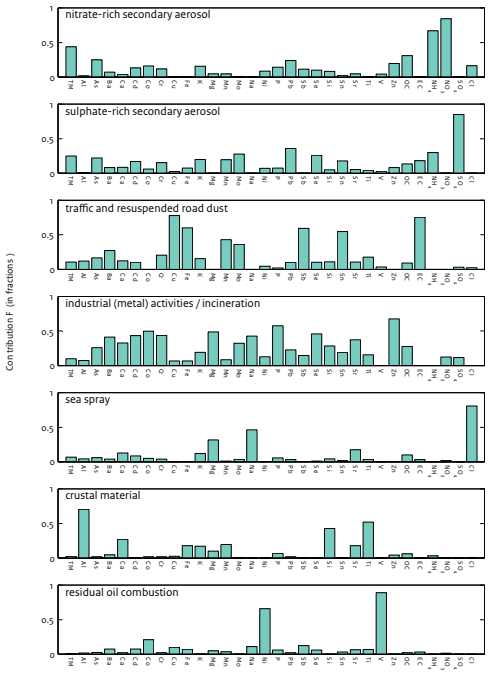
Published by
National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
www.rivm.com

00138? Studio MediaWeb

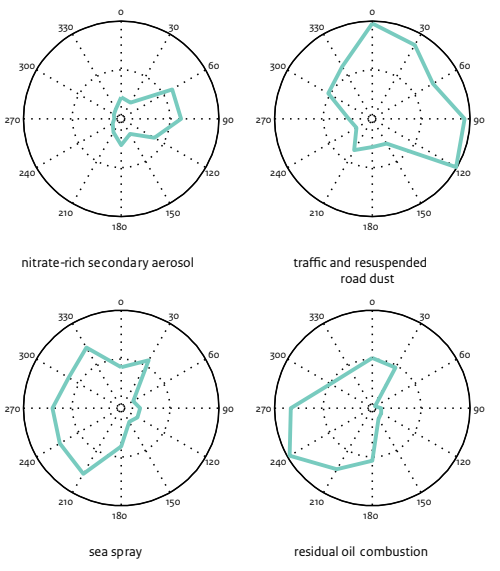
- Daily $PM_{2.5}$ samples were analyzed for a suite of chemical species, secondary inorganic aerosol, EC/OC and total mass.

Data preprocessing

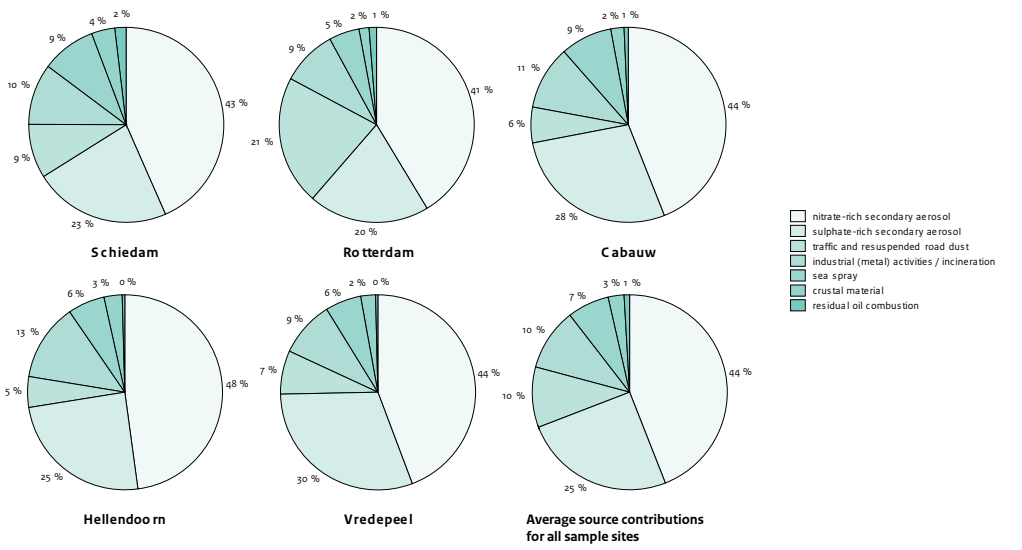
- Approximately 6% of data was missing, specifically for the species Cl^-, NH_4^+, NO_3^-, SO_4^{2-}, OC and EC.
- Multiple imputation technique was used to provide estimates for the unknown concentrations unknown concentrations. Derived uncertainties were multiplied by a factor 4 to downweight the influence on the solution.



Figuur 2: The calculated source profiles for the $PM_{2.5}$ dataset showing the contribution, expressed in fractions, of each species in the profiles. The profiles presented are average profiles for the used receptor sites. The name in the profiles reflects the source identification.



Figuur 3: Examples of Conditional Probability Function (CPF) plots for the nitrate-rich secondary aerosol, traffic and resuspended road dust, sea spray and residual oil contributions at Rotterdam.



Figuur 4: Source contributions expressed in percentages of apportioned $PM_{2.5}$ mass for the 5 monitoring sites in the Netherlands and the combined average contributions for all sample sites.

- Days without results for the ICP-MS analysis have been omitted.
- Data with a lesser validation status were included but their influence on the solution has been downweighted.
- Concentrations below MDL were replaced with half the MDL, corresponding uncertainty was set to 5/6 times the MDL.
- Chemical species containing more than 90% values below the MDL were excluded.
- Signal-to-noise ratio used as categorization indicator.
- Data from 5 sites combined into one dataset (assumption: not much variance between elemental compositions of the "*global*" sources affecting each site).

Results

- After evaluating the number of factors the seven factor solution yielded the most physical understandable results.
- Source identification based upon the chemical constituents in the calculated source profiles (figure 2).
- Identification checked with wind directional analysis (Conditional Probability Function (CPF) plots, figure 3).
- Wind directional analysis show secondary aerosol is mostly contributed from East, corresponding to contributions from the inland.
- Highest contribution of sea spray is from the West (North Sea).
- Relative contributions, expressed in percentages, of all sources to the total mass on each site are given in figure 4.
- Nitrate-rich and sulphate-rich secondary aerosol: highest contribution on the total $PM_{2.5}$ mass on all five sites, on average 44% and 25% respectively.
- Small spatial variability was found for almost all sources (results not shown).
- Traffic and resuspended road dust showed a larger variability (mostly due to the fact the kerbside site is the only site heavily influenced by traffic).

Conclusions

- Seven unique sources for the $PM_{2.5}$ fraction could be identified: nitrate-rich secondary aerosol, sulphate-rich secondary aerosol, traffic and resuspended road dust, industrial (metal) activities / incineration, sea spray, crustal material and residual oil combustion.
- SIA is responsible for the largest contribution on all five sites. The contribution on all sites remains fairly constant.
- Highest contribution of the traffic related sources on the kerbside location.
- Result of the winddirectional analysis correspond with the expected locations of possible sources.
- Combining the data from five sites provides focus on "*global*" sources affecting these sites. Contributions from local sources are distributed among the found source profiles and cannot be distinguished using this approach.

Literature

Schaap, M.; Weijers, E.P.; Mooibroek, D.; Nguyen, L., (2010), *Composition and origin of Particulate Matter in the Netherlands, Results of the Dutch Research Programme on Particulate Matter,* PBL Report 5000099011