Source Apportionment of Polycyclic Aromatic Hydrocarbons at Rural Sites of Ontario Canada

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Abstract

Positive Matrix Factorization (PMF) was used to identify sources of Polycyclic Aromatic Hydrocarbons (PAH) sampled at three rural sites in Ontario, Canada. Combined gas and particle phase PAH samples are collected under the National Air Pollution Surveillance (NAPS) Program of Canada with 24 hour integrated samples analyzed at 6 day intervals. 22 of the 29 PAH species analyzed were used in source apportionment study. PMF analysis showed that the three stations (Egbert, Simcoe and Pt.Petre) were under influence of six, six and seven factors, respectively with all three stations under influence of six similar sources identified as coal combustion, wood combustion, oil combustion, highway traffic, urban traffic and a mixed source. One source unique to Pt.Petre was tentatively identified as other fuel combustion and attributed to marine vessel traffic.

Introduction

Polycyclic Aromatic Hydrocarbons mainly originate from incomplete combustion of fossil fuels [1]. Most of the PAHs are ubiquitous pollutants and several PAHs are known carcinogens or are the precursors to carcinogenic daughter compounds [2]. Once PAHs are emitted, they redistribute between gas and particle phases and are removed by oxidative and photolytic reactions and by dry and wet deposition [3]. Two basic modelling approaches have been generally used for the identification and apportionment of pollutant sources: source-oriented models and receptor models. Receptor modelling by the chemical mass balance (CMB) model requires specific profiles for sources of local relevance. In contrast, positive matrix factorization (PMF) modelling can be applied without a priori knowledge of source profiles but requires time series data of sufficient length. PMF is a multivariate factor analysis tool that decomposes a matrix of speciated sample data into two matrices—factor contributions and factor profiles—which then need to be interpreted by an analyst as to what source types are represented using measured source profile information, wind direction analysis, and emission inventories. In PMF, species with missing or below detection limit values are included by assigning large uncertainties, and therefore a small weight, to these data.

PAH samples are collected both in urban and rural atmospheres in Canada, under the National Air Pollution Surveillance (NAPS) Network Program. In this study, sources of PAHs in three rural sites -Egbert, Simcoe and Pt.Petre- of Ontario were determined by using Positive Matrix Factorization (PMF).

Materials & Methods

NAPS monitoring stations use a two-filter sampler: a glass-fiber filter is used to sample particle phase PAHs while a Polyurethane Foam (PUF) filter is used to sample PAHs present in vapour phase. Vapour and particle phase PAH samples are extracted together. Samples are then analysed for 31 PAHs with GC-MSD. 24 hour integrated samples are obtained every 6 days. Sampling locations, sampling period, and the number of samples used in the PMF analysis for all three stations are given in Table 1.

Table 1. Sampling Locations and Data Set Information

Sampling Site	Longitude and Latitude	Sampling Period	Total Number of Samples
Egbert	44.23 N, -79.78 W	1998-2006	216
Simcoe	42.85 N, -80.27 W	1996-2006	232
Pt.Petre	43.86 N, -77.15 W	1996-2006	263

Results

In all three stations 22 PAHs were used for final PMF analyses. Model solutions using between four and eight factors were performed for each of the rural stations. The best solutions for Egbert, Pt.Petre and Simcoe were with six, seven and six factors, respectively. When correlations between factor profiles from different stations are sought in the form of scatter plots, correlations coefficients between 0.37 and 0.97 are observed. This enables the identification of some (though not all) profiles as representing the same source.

Among the factor profiles identified for the rural stations, six factors were ultimately deemed to be common to all three stations: coal combustion, wood combustion, oil combustion, urban traffic emission, highway emission and mixed combustion. A unique factor determined in Pt.Petre has signs of fuel combustion and hence named as other fuel combustion factor and attributed to marine vessel traffic.

Table 2 summarizes the contributions by the identified factors at the three rural stations in terms of the share of a particular source at a given station. Mixed combustion sources seem to be the most important PAH source over the region. The share of the Urban Traffic factor is fairly consistent around 13% for the three sites whereas the share of the Highway Traffic factor is twice as large in Simcoe, compared to Egbert, and nearly three times the contribution at Pt.Petre. Similarly, while wood combustion shares are in a narrow range (12-18%) for the three stations, the share of coal combustion at Egbert is more than three times the share at Pt.Petre.

Table 2. Contributions to total PAH by identified factors

	Egbert (%)	Simcoe (%)	Pt. Petre (%)
Coal combustion	20.8	12.6	6.5
Wood Combustion	12.7	13.1	18.0
Oil Combustion	6.8	7.6	2.6
Urban Traffic Exhaust	13.0	13.1	13.5
Highway Traffic Exhaust	15.3	33.4	12.1
Mixed Sources	31.4	20.1	37.5
Other Fuel Combustion	-	-	9.8

References

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