

Wood combustion contribution to PM: results of three winter campaigns (2005-2007) in Lombardy (Italy)

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Introduction

Recent studies identify wood burning as an important source of particulate matter.

In Lombardy (Northern Italy), where wintertime PM10 concentration frequently exceeds the EU daily limit of 50 µg/m³, emission inventories estimate that on average 28% of primary PM10 and 31% of primary PM2.5 can be ascribed to wood burning (INEMAR 2005).

Levoglucosan, emitted only by cellulose pyrolysis, has been recommended as a single tracer for the estimation of wood combustion to PM10 emission (Simoneit et al., 1999, Schmidl et al., 2008).

The Analytical Technique

Levoglucosan, together with other anydrosugar compounds, including Mannosan and Galactosan, was quantified using HPAEC-PAD method (Engling et al., 2006; Caseiro et al., 2007).

A modified instrumental set-up was used to improve the performance of the analytical technique. Our method for HPAEC-PAD analyses in PM samples was optimized with the post column addition of concentrated sodium hydroxide, which allowed a better detector response. Moreover, in order to use an isocratic pump, the instrument was equipped with a system for the regeneration of the analytical column. The scheme of instrument set-up is reported in figure 1 (Piazzalunga et al. J. Chromatography A – Submitted).

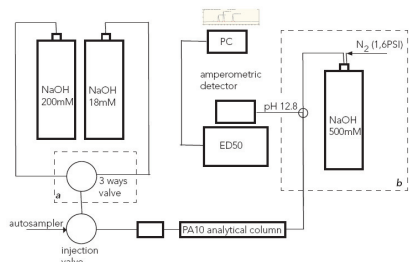


Figure 1

With this analytical set-up, we obtained very low detection limits, so that little portions of the PM filter can be used for the analytical quantification (1.5cm² for 24 hour samples).

The detection limits for Levoglucosan, Mannosan and Galactosan are reported in table 1.

	Levoglucosan	Mannosan	Galactosan
LOD (µg/mL)	0.002	0.001	0.001
LOD (µg/m ³) ^a	0.004	0.003	0.003

^a sampling flowrate = 1m³/h sampling time = 24h

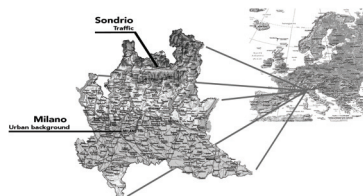
Table 1

OC and **EC** were also quantified by TOT method (Birch and Cary, 1996; Fermo et al., 2006).

References

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Sampling sites



In this study two different urban sites in Northern Italy were investigated: 1) Milan (about 1.500.000 inhabitants), which is located in the Po Valley; 2) Sondrio (22.000 inhabitants), which is a small alpine city.

PM10 samplings were carried out in parallel in Milan and Sondrio (70 samples in total) during three winter periods (years 2005-2006-2007).

Results

		Milano		Sondrio		Milano		Sondrio		Milano		Sondrio	
		mean	σ	mean	σ	mean	σ	mean	σ	mean	σ	mean	σ
PM	µg/m ³	73	25	47	8	78	25	104	17	122	17	70	24
OC	µg/m ³	12.0	4.1	10.6	1.3	18.9	6.1	28.4	7.2	20.4	5.5	19.2	5.1
EC	µg/m ³	2.7	1.0	3.8	0.6	5.6	2.3	6.9	1.3	5.1	1.3	3.7	0.7
TC	µg/m ³	14.6	5.0	14.4	1.7	24.5	8.0	35.3	7.5	25.5	6.6	22.8	5.3
Levoglucosan	ng/m ³	385	180	702	114	1211	598	2301	674	881	444	1524	445
Mannosan	ng/m ³	165	84	337	142	129	86	337	142	129	86	208	67
Galactosan	ng/m ³	40	23	112	42	40	23	112	42	33	19	70	20

Table 2

PM10 mass, Organic Carbon (OC), Elemental Carbon (EC); Total Carbon (TC), Levoglucosan, Mannosan, and Galactosan concentrations recorded during the investigated periods are summarized in table 2.

The biomass-burning fraction of OC and EC (OC_{bb} and EC_{bb}) was estimated as follows:

$$OC_{bb} = \frac{lev}{(lev/OC)_{ER,bb}}$$

$$EC_{bb} = OC_{bb} \cdot (EC/OC)_{ER,bb}$$

Source profiles for European wood are still quite scarce, in this work the emission ratios estimated in two European studies (Szidat et al. 2007, Puxbaum et al. 2007) were used:

$$(lev/OC)_{ER,bb} = 0.15$$

$$(EC/OC)_{ER,bb} = 0.16$$

It is noteworthy that the $(lev/OC)_{bb}$ and $(OC/EC)_{bb}$ values can vary by one order of magnitude depending on the wood type and the burning conditions (Simoneit et al. 1999).

The percentages of OC_{bb} and EC_{bb} are reported in figures 2 and 3 (error bars correspond to one standard deviation).

The fraction of soft- and hard-woods was estimated from the Levoglucosan to Mannosan ratios in ambient PM following the approach of Schmidl et al. (2008):

$$\%spruce = \frac{(14.8 - R_{levo/man})}{0.112}$$

Percentages obtained on our PM10 samples are reported in table 3.

Percentage of OC_{bb} in PM10

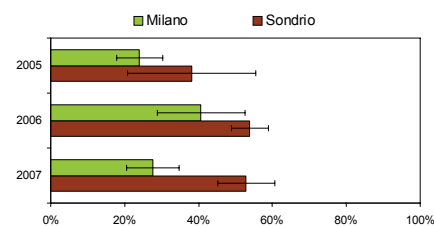


Figure 2

Percentage of EC_{bb} in PM10

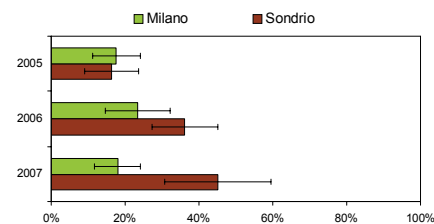


Figure 3

% spruce

	2006	2007
milano	65%	64%
sondrio	68%	65%

Table 3

Conclusions

HPAEC-PAD has been identified as a suitable method for the anydrosugars quantification in atmospheric particulate matter.

The contribution of biomass burning to OC is estimated in 24-41% in Milan and 38-53% in the alpine city, while the EC contribution ascribed to this source is 18-23% in Milan and 16-45% in Sondrio.

This study confirms that wood burning, during the winter season, is an important source for particulate matter in the alpine city as well as in the Milan area.