Impact of wood burning emissions on carbonaceous aerosols and PM in the Alpine region

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Wood burning for domestic heating is an important source of carbonaceous aerosols and ambient particulate matter (PM). The importance of wood burning as a source of particulate air pollutants has been shown in many studies carried out in different countries. At locations in the Alpine region during the cold season, wood burning can be the dominating source of carbonaceous aerosols and PM (Szidat et al., 2007; Gilardoni et al., 2011; Piot, 2011).

During the past years, implemented measures for the reduction of PM emissions have been focused in many European countries on road traffic emissions. Conversely, much less attention has been paid to emissions from domestic wood burning. As shown recently by Gianini et al. (2012), average road traffic contributions to PM\textsubscript{10} have in Switzerland declined during the past ten years, whereas the contributions from wood burning remained unchanged. As a consequence, the contribution of wood burning to PM\textsubscript{10} is today comparable to (or even higher than) the contributions from road traffic on annual average at many locations in Switzerland. Same results are observed in France by Piot (2011).

This presentation provides an overview of the impact of wood burning emissions on carbonaceous aerosols and PM in the Alpine region. The overview is based on results of recently published studies using different methods, such as multivariate statistical models (Positive Matrix Factorization, PMF), Chemical Mass Balance (CMB), \textsuperscript{14}C-method and evaluation of the wavelength dependence of the optical aerosol absorption (Aethalometer model). In addition, available data of specific wood combustion tracers such as levoglucosan are used together with published source emission ratios and PMF-derived emission ratios in macro-tracer analyses to estimate contributions of wood burning emissions to carbonaceous aerosols and PM.

As an example, Fig. 1 shows average wood burning contributions to PM\textsubscript{10} as derived by PMF versus average concentrations of levoglucosan at sites in Switzerland and in Milan (Northern Italy; data from Piazzalunga et al., 2011). The content of levoglucosan in PM\textsubscript{10} from wood burning is constant for the Swiss sites that are located north of the Alps (Bern, Zurich, Payerne; levo/PM\textsubscript{10\_WB} = 0.045) and clearly lower than at the Swiss site south of the Alps (Magadino; levo/PM\textsubscript{10\_WB} = 0.069) and in Milan (Piazzalunga et al., 2011; levo/PM\textsubscript{10\_WB} = 0.059). These and other PMF-derived emission ratios are used for estimation of wood burning impacts on particulate air pollutants and for comparison with results obtained by other source apportionment approaches.
Figure 1. PMF-derived average contribution of PM10 from wood combustion versus average concentration of levoglucosan at sites in Switzerland and in Milan, Northern Italy.

References


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Introduction

The importance of wood burning as a source of particulate air pollutants in the Alpine region is known from various studies (see references below).

An overview of the contribution of wood burning to elemental carbon (EC\textsubscript{WB}) and particulate matter (PM\textsubscript{WB}) in the Alpine region is given:

a. based on published values for EC\textsubscript{WB}, OC\textsubscript{WB} and PM\textsubscript{WB} and

b. based on the relation between EC\textsubscript{WB}, OC\textsubscript{WB} and PM\textsubscript{WB} as derived from source apportionment models (PMF, aethalometer model, \textsuperscript{13}C) and the measured concentrations of the specific organic tracers levoglucosan and mannosan (see figures below; broken and solid lines indicate 95% confidence- and prediction interval of linear regression calculation, uncertainties (see table) were estimated from prediction intervals).

The latter allows estimation of EC\textsubscript{WB}, OC\textsubscript{WB} and PM\textsubscript{WB} at sites where measurements of levoglucosan and mannosan are available.

Results

Summary of measured concentrations of levoglucosan, the ratio of levoglucosan and mannosan and estimates for the average contribution of wood burning emissions to ambient EC, OC and PM:

<table>
<thead>
<tr>
<th>Site</th>
<th>Country</th>
<th>Type</th>
<th>PM\textsubscript{WB}</th>
<th>Season</th>
<th>EC\textsubscript{WB}</th>
<th>PM\textsubscript{WB}</th>
<th>OC\textsubscript{WB}</th>
<th>PM\textsubscript{OC}</th>
<th>Levo/Manno</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zurich</td>
<td>CH</td>
<td>urban backgr.</td>
<td>10 winter 2008/09</td>
<td>6.8</td>
<td>1.1±0.2</td>
<td>4.7</td>
<td>2.0±1.4</td>
<td>0.5</td>
<td>2.5±0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Granollers</td>
<td>CH</td>
<td>rural</td>
<td>10 winter 2008/09</td>
<td>12.1</td>
<td>1.6±0.6</td>
<td>2.9</td>
<td>2.9±1.4</td>
<td>0.6</td>
<td>2.8±0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Mollereaux</td>
<td>CH</td>
<td>rural</td>
<td>10 winter 2008/09</td>
<td>19.4</td>
<td>2.7±0.9</td>
<td>3.2</td>
<td>2.3±1.4</td>
<td>0.7</td>
<td>2.8±0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Milan</td>
<td>IT</td>
<td>urban</td>
<td>10 winter 2008/09</td>
<td>40.0</td>
<td>4.7±1.7</td>
<td>3.9</td>
<td>2.3±1.4</td>
<td>0.6</td>
<td>2.8±0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Roveredo</td>
<td>IT</td>
<td>rural</td>
<td>2.5 Feb 2009</td>
<td>16.6</td>
<td>4.9±1.2</td>
<td>3.9</td>
<td>2.3±1.4</td>
<td>0.6</td>
<td>2.8±0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Passy</td>
<td>CH</td>
<td>urban backgr.</td>
<td>10 winter 2008/09</td>
<td>4.5</td>
<td>0.9±0.1</td>
<td>0.5</td>
<td>2.3±1.4</td>
<td>0.6</td>
<td>2.8±0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>St. Gallen</td>
<td>CH</td>
<td>rural</td>
<td>10 winter 2008/09</td>
<td>27.0</td>
<td>3.7±1.2</td>
<td>3.0</td>
<td>2.3±1.4</td>
<td>0.6</td>
<td>2.8±0.2</td>
<td>3.0</td>
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<td>3.0</td>
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</table>

Conclusions

- Wood burning is a main source of particulate air pollutants in the Alpine region.
- Highest contributions from wood burning can be found in Alpine valleys.
- Large variability: Relative contribution of wood burning to total OC ranged from 91-99% (for EC range is 10-70%)
- Uncertainties for PM\textsubscript{WB} in our estimations are high because of small number of available “calibration points” (blue points in upper figure).

Bar charts summarising EC\textsubscript{WB}, OC\textsubscript{WB} and PM\textsubscript{WB} at the sites in the Alpine region as taken from literature and as estimated in this study.

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