Road Dust resuspension and toxic components

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Background

Several studies in Spanish urban areas have shown high concentrations of aerosol particles. These air pollution problems are in most cases attributed to traffic. Traffic emissions include exhaust origin particles, as well as particulate matter from abrasion sources like tire and brake wear debris and particles resuspended by the road surface. Street washing is one of the methods that might reduce the occurrence of dust re-entrainment by reducing the amount of dust on the road. In recent years, street washing and responsible for the elevated levels of particles (Artirino et al., 2004, Querol et al., 2004, Salvador et al., 2004). Since 2007 the local authorities implement street washing in a major part of the urban region of Madrid. However, an exhaustive study in order to examine the effect of this method to the air quality has not yet been conducted.

The aim of this study was to quantify the contribution of road dust to particulate matter, and evaluate the effects of street washing on the strength of resuspension.

Study Area

An intensive sampling campaign was conducted during summer 2009 in central Madrid. Aerosol monitoring included air quality measurements at two traffic sites, ALCALA and MALDONADO along one busy street placed 1.5 km apart and at one fixed site, named ESCUELAS AGUIRRE monitored by the Madrid City Hall authorities, Figure 1.

PM10 Chemical components

PM10 daily samples were subjected to chemical analysis by the procedure described in Querol et al., 2001 in order to identify any differences in the hazardous components of ambient particulate matter when street washing is occurring in urban areas.

For Maldonado and Escuelas Aguirre sampling sites the difference between the sampling days with and without street washing was insignificant for the water soluble ions, Table 2.

Major metals like Ca, Al, K, Na and Mg that are emitted in the atmosphere during abrasion processes have showed a reduction during SW days. For trace elements like Pb, Sn, Zn and Ba, considered to be emitted from non-exhaust sources, a statistically significant difference of 10% was observed. For Alcala site the differences in mass concentrations were more pronounced. In this case, for these typical traffic tracers the reduction in mass concentrations for the days that street washing occurred was higher than 30%.

Table 2: Average concentrations of major and trace elements in daily PM10 samples

<table>
<thead>
<tr>
<th>Element</th>
<th>Average MALDONADO</th>
<th>Average ALCALA</th>
<th>Average ESCUELAS AGUIRRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>6.05</td>
<td>3.88</td>
<td>4.40</td>
</tr>
<tr>
<td>Mn</td>
<td>2.07</td>
<td>1.48</td>
<td>1.76</td>
</tr>
<tr>
<td>Cr</td>
<td>0.60</td>
<td>0.41</td>
<td>0.47</td>
</tr>
<tr>
<td>Ni</td>
<td>0.41</td>
<td>0.29</td>
<td>0.37</td>
</tr>
<tr>
<td>Cu</td>
<td>0.25</td>
<td>0.20</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Methodology

During the six-months campaign the following procedure was used:

- PM10 mass concentrations were measured using continuous and gravimetric samplers placed at the same height above the road and the next week the road was left untreated to obtain any potential increase in PM concentration and particle washout from the road. This was repeated for both the traffic sites.
- Road the sampling was conducted in ALCALA, see Figure 1, where the road surface was untreated. After a 6-month period of untreated road, the sampling was repeated on treated sites with the same protocol as described in Arteiro et al., 2009.
- The road dust washing protocol included two sampling periods: before and after the street washing. The procedure followed for determining the dust deposits, road dust loadings and the supersaturation of resuspended particles is depicted in Figure 2.

PM continuous mass concentrations

Figure 4. Daily variability of PM10 and PM2.5 concentrations between SW days and no SW days for MALDONADO a) and b) and ALCALA sampling site c) and d).

The daily evaluation of PM levels was evaluated in order to detect out any short term effect of street washing. Continuous measurements were separated into two subsets: 15 days with street washing and 16 days without street washing. Figure 4. For MALDONADO a clear difference was established between these two periods for the early morning hours until early in the afternoon (00:00-16:00). However, this trend was not observed from 16:00 to 24:00 h. The mass difference between the two periods was about 10 mg m(^-2) for PM2.5 fraction, about 10% of the measured mass concentrations.

For the second sampling site, ALCALA, the difference between the two periods was observed from the early morning hours until 12:00, while this difference in terms of mass concentration was about 10 µg m(^-3) for PM10 fraction, about 10% of the measured mass concentrations.

Source Apportionment

Positive Matrix Factorization was used to interpret chemical composition of PM10 data, so the contribution of different sources to suspended particles could be calculated. For this reason 24h PM10 data from the three sites (Maldonado, Alcala and Escuelas Aguirre) were combined. The best results were obtained when four factors were selected: vehicles emissions, secondary aerosol, road dust and soil. As it was expected vehicles emissions along with road dust were the major contributors in PM10 particulate matter, Figure 5.

Then the daily variation of the source contribution was examined. The effect of street washing was evaluated by examining the daily variation of the road dust contribution between SW days and no SW days. The results revealed a reduction in the road dust load, soil and vehicles emissions of about 25%, Table 3. On the other hand the secondary aerosol contribution had a different trend, during the SW days the contribution increased about 15%.

PM10 source contribution

Table 3. Source contribution between SW days and no SW days

<table>
<thead>
<tr>
<th>Source</th>
<th>PM10 contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road dust</td>
<td>18%</td>
</tr>
<tr>
<td>Soil</td>
<td>18%</td>
</tr>
<tr>
<td>Secondary aerosol</td>
<td>31%</td>
</tr>
<tr>
<td>Vehicles emissions</td>
<td>31%</td>
</tr>
</tbody>
</table>

Figure 5. Source contribution (%) calculated by PMF for the urban area of Madrid.

Though it merits further inquiry in future work, for the purpose of adopting strategies for the reduction of PM levels, we conclude that street washing has been a positive effect. The results of the present study indicate that resuspension and street washing activities correlate positively.

Future work

The future work will incorporate the road dust chemical analysis results and the calculation of the emission factors.

Acknowledgments

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