Hourly measurements of the lead content in atmospheric suspended particles at an urban station of Sabadell City (Catalonia, Spain)

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Abstract

Lead was classified as a category-one pollutant in the 1st EU programme of action in environmental matters. In 1978 the EU adopted the directive 78/61/ECC which limited the level of lead in petrol to 0.4 g/l. This directive was reinforced by the directive 85/210/ECC, which obliged EU Member States to reduce the level of lead to 0.15 g/l. The percentage of unleaded gasoline consumption in EU countries during 1995 was 67\%, and in specifically in Spain it was only 29\%. This is specially important in urban areas. A set of measurements of the lead content in atmospheric suspended particles is presented. An experimental campaign of one week in December of 1995 in the city of Sabadell (Catalonia, Spain) was carried out in the frame of work developments for the elaboration of the Air Quality Daughter directive on lead. The evolution of the daily cycle at a hourly frequency has been studied and its correlation with the average hourly traffic was highly correlated. The concentrations are also compared, using two different sampling methods: high volume sampler vs medium volume sampler. Results obtained manifest that the concentrations of lead in atmospheric suspended particles inside urban centres are due to traffic, because of the use of leaded gasoline.
1 Introduction

Lead is one of the oldest metals known to man and, since roman and medieval times, has been used in piping, building materials, solders, paint, ammunition and castings. In more recent times lead has been used mainly as additive to gasoline, in storage batteries, metal products, and pigments.

Lead is generally considered as an ubiquitous health hazard for humans and as the most harmful heavy metal in the air of cities in developed countries. Lead is introduced in air mainly through its use as an additive to gasoline, in the form of organic lead compounds: tetraethyl and tetramethyl lead to achieve desired octane numbers. Lead alkyl additives in gasoline are combusted and emitted into the atmosphere, and can be responsible for the presence of lead in air, some vegetation, road soil lead, water and plants. In countries where gasoline that contains lead is still used, atmospheric lead pollution from motor vehicle exhaust aerosols is a major source of lead pollution (Grobler et al 1992, Pönkä et al 1993, Simmons and Knap 1993, Piron-Frenet et al 1994). Also, many metal smelters (lead, copper, zinc, iron, steel) emit significant amounts of lead to the atmosphere. Lead occurs in the atmosphere mainly in particulate form.

The previously very widespread use of lead in gasoline has been substantially reduced in United States, Japan and Europe, because of the use of lead-free gasoline by catalyst car. Although unleaded gasoline has been available since the 1970s in the United States, Canada and Japan, only since 1985 the European Union required the maximum lead content in gasoline to be reduced to 0.15 g/l (directive 85/210/ECC,). This measure has led the way to a fall the ambient air lead concentrations (Stern 1986, UNEP-WHO 1992, Pönkä et al 1993, Migon et al 1993, 1994, Lee et al 1994, Watanabe et al 1994, Nizich et al 1996, Schuhmacher et al 1996).

The purpose of this study is to present a set of measurements of the lead content in atmospheric suspended particles. An experimental campaign of one week in December of 1995 in the city of Sabadell (Catalonia, Spain) was carried out in the frame of work developments for the elaboration of the Air Quality Daughter directive on lead. The evolution of the daily cycle at a hourly frequency has been studied and its correlation with the average hourly traffic is presented. The concentrations of the lead in atmospheric suspended particles are also compared, using two different sampling methods: high volume sampler vs medium volume sampler.

2 Lead-free gasoline in Europe

The first EC directive establishing emission limits for vehicle exhaust goes back to 1970. Since then emission limits for a number of pollutants have been tightened in successive steps. To that end it is the appearance of the catalytic converter technology that allows us to foresee the possibility of important reductions in the emissions of pollutants (NOx, VOC and CO) caused by the engines running. Without the general
availability of lead-free gasoline the introduction of catalytic converters aimed at reducing exhaust fume emission would have been impossible.

In 1978 the Council of Ministers had adopted the directive (78/611/EEC) limiting the level of lead in petrol to 0.4 g/l. This directive was superseded and reinforced by the directive 85/210/EEC which obliged Member States to reduce the level of lead to 0.15 g/l and guarantee the supply and distribution of unleaded petrol (with a maximum lead content of 0.013 g/l) from the deadline of 1st October of that year.

Details of lead consumption in gasoline in each European Union country during 1995, are presented in the table 1.

Table 1. Estimated elemental lead use in gasoline in the EU (1995)

<table>
<thead>
<tr>
<th>Country</th>
<th>Gasoline demand (10³ tonnes)</th>
<th>Leded (10³ tonnes)</th>
<th>Unleaded (10³ tonnes)</th>
<th>Lead level (g/l)</th>
<th>% unleaded</th>
<th>Pb use (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>2,400</td>
<td>0</td>
<td>2,400</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Belgium</td>
<td>2,792</td>
<td>838</td>
<td>1,954</td>
<td>0.15</td>
<td>70</td>
<td>170</td>
</tr>
<tr>
<td>Denmark</td>
<td>1,848</td>
<td>0</td>
<td>1,848</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Finland</td>
<td>1,838</td>
<td>0</td>
<td>1,838</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>15,494</td>
<td>7,713</td>
<td>7,781</td>
<td>0.15</td>
<td>50</td>
<td>1,562</td>
</tr>
<tr>
<td>Germany</td>
<td>29,686</td>
<td>1,781</td>
<td>27,905</td>
<td>0.15</td>
<td>94</td>
<td>361</td>
</tr>
<tr>
<td>Greece</td>
<td>2,574</td>
<td>1,751</td>
<td>823</td>
<td>0.15</td>
<td>32</td>
<td>355</td>
</tr>
<tr>
<td>Holland</td>
<td>3,960</td>
<td>594</td>
<td>3,366</td>
<td>0.15</td>
<td>85</td>
<td>120</td>
</tr>
<tr>
<td>Ireland</td>
<td>1,024</td>
<td>446</td>
<td>578</td>
<td>0.15</td>
<td>56</td>
<td>90</td>
</tr>
<tr>
<td>Italy</td>
<td>16,438</td>
<td>9,698</td>
<td>6,740</td>
<td>0.15</td>
<td>41</td>
<td>1,964</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>502</td>
<td>95</td>
<td>407</td>
<td>0.15</td>
<td>81</td>
<td>19</td>
</tr>
<tr>
<td>Portugal</td>
<td>1,889</td>
<td>1,216</td>
<td>673</td>
<td>0.40</td>
<td>36</td>
<td>657</td>
</tr>
<tr>
<td>Spain</td>
<td>8,172</td>
<td>5,802</td>
<td>2,370</td>
<td>0.15</td>
<td>29</td>
<td>1,175</td>
</tr>
<tr>
<td>Sweden</td>
<td>4,192</td>
<td>0</td>
<td>4,192</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>21,960</td>
<td>8,127</td>
<td>13,833</td>
<td>0.15</td>
<td>63</td>
<td>1,646</td>
</tr>
<tr>
<td>Totals</td>
<td>114,769</td>
<td>38,061</td>
<td>76,708</td>
<td>-</td>
<td>67</td>
<td>8,119</td>
</tr>
</tbody>
</table>

Source: LDA (1996)
Sabadell is a city located in the metropolitan area of Barcelona (Catalonia, Spain), with about 200,000 inhabitants. In December 1995 it was made a field experimental campaign measuring the content of lead in atmospheric suspended particles, following the evolution of the daily traffic cycle in a station of the afore mentioned city, that was considered representative of the traffic conditions.

In the Figure 1 it was represented the average hourly intensity of the vehicles. It can be observed that there are three peaks at day hours: 1) from 7am to 9am; 2) from 1pm to 3pm (Spanish lunch time); and 3) from 7pm to 8.30pm. The night valley is really important, with almost no traffic between 3am and 4am.

The average daily traffic was 25,211 (number of vehicles/day), and for each way 11,644 and 13,567.

Figure 1. Hourly traffic intensities in the traffic measure station.
4 Measures of lead content in atmospheric suspended particles

The content of lead in the atmospheric suspended particles was measured using two different sampling methods: high volume sampler vs medium volume sampler. After, both series of samples, was analysed in the laboratory by acid digestion (USEPA 40-CR50) and atomic absorption spectroscopy (AAS).

The correlation between the two series of experimental results obtained with the different sample collection can be considered good, showing a correlation coefficient of 0.66. It should be considered that they are experimental measurements at a field and not from the laboratory (Figure 2).

![Figure 2. Comparison between lead concentrations in atmospheric suspended particles from high volume and medium volume samplers](image.png)
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The range of the measures is between 0.1 and 0.7 \( \mu g/m^3 \), being the maximum in the central hours of the day. In the Figure 3 it has been represented five daily cycles corresponding to the workday of the week (Monday to Friday). It can be observed that the lead levels in the atmospheric suspended particles of the first four days is the same with a little tendency to decrease, but there are levels clearly higher on Friday. Also, it is evident the high correlation between the traffic cycle and the lead concentration in the atmospheric suspended particles.

In the EU the present air quality limit for the lead in the atmosphere is 2 \( \mu g/m^3 \) (annual average), while the World Health Organization (WHO) has a guideline of 0.5 \( \mu g/m^3 \) (annual average). Except for one measure, all the measures are under 0.5 \( \mu g/m^3 \) (four hours period).

![Figure 3. Comparison between the lead concentrations in atmospheric suspended particles and the traffic.](image-url)
Acknowledgements

The authors acknowledge the technical support giving by Teresa Lacorte in the sample collection process.

References


