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Seasonal analysis of air pollution levels in Madrid

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Abstract

Madrid city has a high density of population and suffers from chronic congestion problems. It means that some pollutants could produce atmospheric emergency situations when weather stability periods last longer. Due to the low level of industry in the region, mobile sources have an important contribution to total emissions. Madrid has a 20-year-old air pollution control network which is composed of 24 permanent stations which control all pollutants and atmospheric variables. This paper analyses inmission values from 1990 to 1997. The analysis covers main pollutant values and their variations within the week and between seasons. The study has a twofold approach: mean-daily values and semi-hourly values. The results allow to draw some conclusions about inmission values in different areas of the city and how traffic-flow contributes to them.

Keywords: Air pollution; Traffic flow; Emission

1. Introduction

There have been many studies carried out to measure roadside emission levels, but it should be noted that it is very difficult to determine pollutant emissions released into the city air from traffic on a regional level. This is precisely one of the goals of the EMMA[1] project conducted in Madrid, namely, to calculate real levels and trends

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[1] EMMA Project is part of the 'Telematics for Environment' Program, financed by the European Commission. The full name is 'Integrated environmental monitoring and forecasting and warning systems in metropolitan areas' (Project EN 1005).

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with regard to different traffic policies in the region.

Air pollution problems in Spanish urban areas are to a large extent a consequence of traffic: almost 90% of carbon monoxide emissions correspond to mobile sources, and in the case of nitrogen oxides, this proportion is approximately 75%. The concentration of urban settlements, particularly in Madrid, produces high traffic volumes in the city and its suburbs.

There are two factors that can make the situation even worse. Firstly, the process of new settlements in the suburbs, where density is lower, and secondly, the increase in motorization rates, which is now some 400 vehicles/1000 inhabitants.

2. Air pollution in the Madrid region

Air pollution control in the region is under the jurisdiction of the Madrid Regional Government. However, the Municipality of Madrid has been monitoring pollutants for a long time. Since 1978, Madrid city has availed of a network of 24 monitoring stations oriented to measure concentration levels. The stations provide check-outs on the concentration levels of seven pollutants, including NO_x, NO_2 and CO, and some other meteorological parameters. This network can then be regarded as headquarters for the screening of pollution levels in Madrid. The situation in the capital is made even worse by the fact that the biggest atmospheric hazards take place in Madrid city, specially in winter time, when weather conditions are likely to be stabilised for longer periods, and highest traffic flows are recorded.

Data collected over the last 20 years show a significant reduction in concentration levels of the different pollutant — just like in other European cities. This fact can be explained by the enforcement of new common directives as regards emissions from vehicles, the renewal of the 'mobile park', and the change in the fuel used in house heating systems.

CO and hydrocarbon levels are normally kept at bay under permitted limits. However, in those periods when atmospheric conditions are less favourable for diffusion, the CO levels usually go over the limit in intersections and junction points located in the central area of Madrid normally suffering from high traffic density.

Presently, the greatest threat is NO_x levels, basically attributable to urban transport. Thus, it can be asserted that the distribution of maximum pollution levels from these agents is clearly associated with the areas exposed to highest traffic flows.

3. The conditions of traffic in Madrid

The increase in mobility rates experienced in the Madrid region over the last decade has been significant, both in private car road traffic and in public transport. The more relevant increments have been observed in transport services covering the suburban area, and in the roads of the main and secondary networks. Mobility in Madrid is markedly radial, since close on 58% of mechanised trips recorded in the metropolitan area are originated in or bound for the central districts of the city, namely, the so-called 'Central Almond'.

The total number of regional mechanised trips in an average working day totals 6.5 million, public transport trips accountable for the highest proportion of these movements (Table 1).

Another important aspect worth broaching here is the change in housing settlement base on the use of cars. This fact can be explained by a general two-sided trend: people take up residence out of the city core, but still work in the central areas. Likewise, the location of industrial complexes in peripheral areas brings about radial movements.

Table 1
Daily mobility in the Madrid region (1996 survey)

Public transport	Private cars	Global
3528 (54%)	3018 (46%)	6546000

4. Analysis of inmission levels in Madrid

In order to evaluate the impact of emissions derived from traffic within the global inmission values, it is necessary to have a detailed knowledge of the inmission values corresponding to each station, trying to minimise as much as possible the effect atmospheric variables play on them. It is also essential to confront the reliability of the calculation on emissions, as well as their corresponding assignments. A selection of the daily average values taken from the different pollution control stations in Madrid for the period 1990–1997 were analysed. With a view to minimising the impact of the atmospheric variables, the study has not considered days in which wind speed is over 2 m sec^{-1}, and the relative air humidity is over 70%, as well as those days clearly showing atypical congestion levels, such as Christmas day. Data have been grouped according to the type of activity (working and holiday days), and according to the mean temperature: winter (November, December, January and February), and summer (May, June and July).

5. Conclusions

Comparing concentration values among the stations in different areas, we can conclude that traffic is a highly polluting agent, particularly for CO, particle and NO_x levels. Those stations located in congested areas show higher values, and also big differences between weekdays and weekends. Levels in radial roads appear to be higher during weekends, when people normally take a day out of the city. Also relevant is the impact, at least, in the short, term-of major infrastructure improvements that bring about changes in mobility patterns.

There is, however, a beneficial effect on SO_2 (lower) levels from low sulphur concentration in gasoline, and the new natural gas heating systems.

Finally NO_x seems to be the most dangerous pollutant, because there is no balance among the different oxides which produce O_3. It is also clear that the drop in the level of this pollutant over the last rainy years has not been as significant as the drop in other pollutants.