MODELLING OF THE IMPACT OF CONSUMPTION OF BIOMASS FOR HOME HEATING ON AIR QUALITY IN A DISTRICT OF MADRID CITY

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Summary

In this paper, a CFD model has been applied to analyse the concentration of PM10 at pedestrian level in a district of Madrid City with a resolution of meters. Atmospheric flows and dispersion of pollutants emitted by road traffic and boilers for home heating were simulated for a winter period. The results were compared with experimental data of PM10 concentration recorded at a traffic-oriented air quality station located in the modelled domain. A good agreement between modelled and measured data was obtained. Possible future emission scenarios were then simulated considering different partitioning of fuel consumption (natural gas, gas oil, coal and biomass) for home heating. This study shows that an increased consumption of biomass for home heating can produce a significant increase of PM10 concentrations but much less than in the case of coal. The use of natural gas would reduce the PM10 concentrations. This study also shows the need of suitably regulating the use of biomass fuels and promoting the use of cleaner fuels.

Introduction

In recent years, there has been an increase in the consumption of biomass for home heating, which could have an impact on air quality. In addition, the emissions of biomass boilers for home heating depend on the physical characteristics of the biomass, the boiler technology and filtration systems. Therefore, the use of biomass as a fuel for home-heating boilers in cities should be regulated. Hence, studies for estimating the impact of using biomass for home heating on urban air quality are needed. The aim of this study is to estimate the effect on PM10 concentrations of several emission scenarios where different degrees of implementation of the use of biomass as a fuel for home heating with respect to the current situation. In addition, other scenarios taking into account the consumption of other fuels (coal, gas oil and natural gas) are analysed.

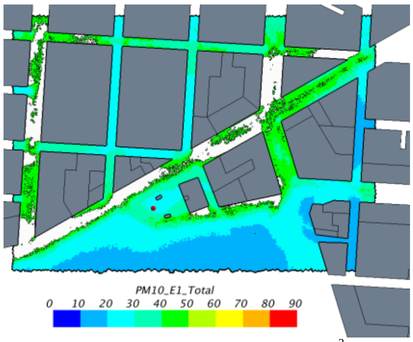

Fig.1 Average PM10 concentrations (µg/m^3) at 3 m above ground level for the period January-March 2011 considering road traffic and boiler emissions and the background concentration. Areas with concentration higher than 50 µg/m^{3}are in white.

Methodology and Results

High resolution maps of average PM10 concentrations over a large period of time (several months) were computed using a CFD model to assess how the pollution is distributed in the streets within a domain of 700 m × 700 m in Madrid City. In order to avoid a large computational load, the approach of Santiago et al. (2013) was adopted. This consisted of running only a set of scenarios (16 inlet wind directions) using steady-state CFD-RANS simulations (STAR-CCM+ code from CD-Adapco). The road traffic emissions were modelled as tracers released from line sources along every street (one for each street) and the emissions of home heating were located on building stacks. The final map of average concentrations was made by combining (weighted average) the outputs of the simulated scenarios according to the meteorological conditions that occurred during the study period (January-March 2011). The resulting PM10 concentration map is shown in Fig. 1. Several scenarios with varying degrees of implementation of the different fuel types were simulated in order to estimate the impact on PM10 concentrations in the study domain. The results are summarized in Table 1. Two emission limits for biomass boilers were adopted: the current one of 150 mg/m^3 and the limit of 60 mg/m^3 to be implemented in the near future. Currently, biomass use is very low and its contribution to PM10 levels is small. However, a high consumption of biomass can produce a significant increase in PM10 levels enlarging the area with exceedances of limit values. Natural gas and coal are the best and worst fuels, respectively, with regards to their contribution to PM10 levels.

Scenario	Fuel usage share in boilers in buildings of the studied domain (%)	Increase of the Surface of área exceeding 50 µg/m^3 of PM10 respect to base scenario	Maximum contribution to the PM10 concentrations due to house heating boilers (µg/m^3)
0 (Base)	Biomass=0.6%; Natural Gas =76.6%; Gas Oil=20.6%; Coal=2.2%	0%	1.8
1.a	Biomass(150 mg/m^3)=25% Natural Gas=75%	20%	6
1.b	Biomass(60 mg/m^3)=25% Natural Gas=75%	3%	2.5
2.a	Biomass(150 mg/m^3)=50% Natural Gas=50%	52%	11
2.b	Biomass(60 mg/m^3)=50% Natural Gas=50%	14%	4.5
3.a	Biomass(150 mg/m^3)=75% Natural Gas=25%	85%	16
3.b	Biomass(60 mg/m^3)=75% Natural Gas=25%	24%	6.5
4.a	Biomass(150 mg/m^3)=100%	117%	21
4.b	Biomass(60 mg/m^3)=100%	38%	8.5
5	Natural Gas=100%	-7%	0.5
6	Coal=100%	278%	55

Table 1. Estimated impact on ambient PM10 concentrations of several scenarios of fuel usage in home heating boilers in Madrid.

Conclusions

An intensive use of biomass as a fuel for home heating boilers is expected to have a significant impact on the ambient PM10 concentrations in urban areas, even in areas with high traffic intensities such as that studied in Madrid.

Acknowledgement

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References

Santiago JL, Martín F, Martilli A (2013) A computational fluid dynamic modelling approach to assess the representativeness of urban monitoring stations. Science of the Total Environment 454-455, 61-72.