The effect of biomass burning on PM exposure during wintertime

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Over the last couple of years, the use of biomass as heating source was allowed in Greece as a CO_2-neutral means of space heating in the large metropolitan areas of Athens and Thessaloniki affecting more than half of the country’s population. At the same time the use of light heating diesel was heavily taxed. In the same period Greece faces a financial crisis with significant repercussions on the average household income. This combination resulted in reduced traffic loads but excessive biomass use for domestic heating. In this context, the current study deals with the assessment of the seasonal variability of PM exposure in the city of Thessaloniki.

A combination of measured and modeled data of outdoor and indoor PM10 and PM2.5 were generated, feeding a composite integrative exposure assessment framework that takes into account indoor air quality modeling, time activity patterns and activity based inhalation rates. The measurements campaign included the assessment of outdoor and indoor air quality and the evaluation of biomass use (in open fireplaces) for domestic heating. Outdoor measurements highlighted a significant increase of PM10 (from 30.1 to 73.1 μg/m^3) and PM2.5 (from 19.4 to 62.7 μg/m^3) concentrations during the transition from the warm to the cold period of the year 2012, in contrast to the previous year (2011) where this transition was accompanied by a smaller increase of 12 μg/m^3 for both PM10 and PM2.5. Between the two years, there is a significant difference in the PM emission patterns; in 2012 the traffic component is reduced, while during the colder period the component associated with the biomass heating dramatically increases. The latter is verified by the positively correlated levoglucosan concentrations to ambient air PM concentrations. Indoor concentrations followed a similar pattern, while in the case of fireplace use, average daily concentrations rise up to 10 μg/m^3 and 14 μg/m^3 for PM2.5 and PM10 respectively. Concentrations tend to rise significantly during the fireplace operation, accompanied by an average increase of 65 and 85 μg/m^3 for PM2.5 and PM10 respectively; however this increase is more prominent in PM of lower aerodynamic diameter as identified by particle size measurements (Figure 1). Average indoor air concentrations seemed to be significantly affected by the outdoor air quality rather than moderate indoor air biomass burning emissions, as estimated by IAQ modeling and verified by the respective measurements.

Personal exposure (Figure 2) is determined by the overall indoor air quality, since people spend about 85% of their time indoors. Tracking intra-day variability (Figure 3), shows that peaks of ambient PM concentrations do not necessarily reflect peaks of actual exposure and intake (red line), since the timing and the location where people perform their activities is also important.

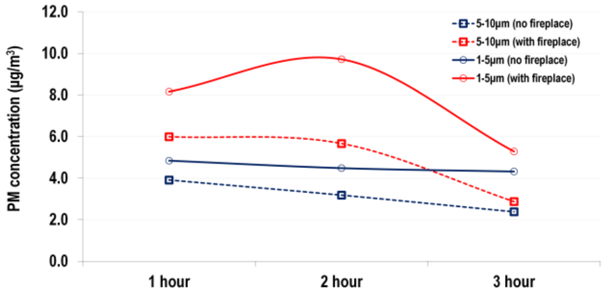

Figure 1. Comparative concentration profiles of open fireplace operation for different PM size fractions (PM1-5 and PM5-10).

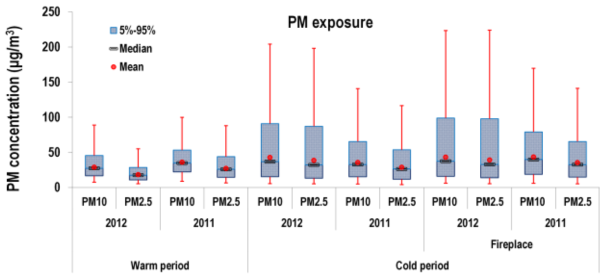

Figure 2. Seasonal variability of exposure to PM for the years 2011 and 2012.

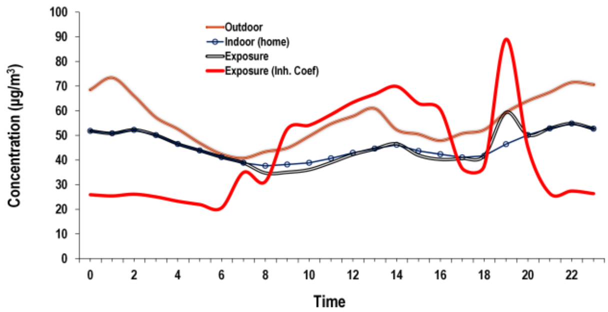

Figure 1. Typical wintertime intra-day variability profile of PM10 concentration and personal exposure.

Late night peaks of ambient PM concentrations (related to domestic heating emissions) do not correspond to peaks of actual intake, since people spend a large part of the time sleeping thus inhalation rate is very low. On the contrary, peaks of exposure (and potential intake) are related to specific activities performed outdoor (e.g. commuting by any transportation means) or indoors (use of open fireplace).