Assessing PM_{10} source reduction in urban agglomerations for air quality compliance

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The objective of this work was to study PM_{10} concentration data available from monitoring stations in three large urban agglomerations in Greece and to estimate the emissions reduction required for compliance with the EU Air Quality Standards for PM_{10} (annual mean concentration less than 40 μg/m^3; 50μg/m^3 not to be exceeded for more than 35 days per year).. The cities studied are namely the Athens and Thessaloniki Metropolitan Areas (AMA and TMA, respectively) and the Greater Volos Area (GVA). The dataset was retrieved from the EEA public air quality database (AirBase) and was gap-filled with data available on line by the Hellenic Ministry of environment, energy and climate change.

PM_{10} concentrations during the period 2001-2009 have been evaluated for 14 air quality monitoring stations (depicted in Table 1) in the three urban areas. Measurements revealed that the concentrations of PM_{10} during the period studied constantly exceeded the threshold values at GVA and at the traffic and industrial stations in TMA and most of the traffic sites in AMA. Most of the occurrences of non-attainment to AQSs were observed during the winter period at all areas (more pronounced for TMA and GVA).

The reduction R in current emission source strength to meet the air quality goal was calculated by the rollback equation (Seinfeld and Pandis, 1998):

$$R = (E\{c\}-E\{c\}_s)/(E\{c\}-c_b)$$

where E{c} is the current annual mean of the pollutant concentration, $E\{c\}_s$ is the annual mean corresponding to the air quality standard c_s, and c_b is the background concentration assumed to be constant. The rollback equation can be applied assuming that changes in emissions levels by a factor of k correspond to the same change in concentration levels. The source distribution remains the same and the pollutant is non- reactive. The methodology was applied to daily averaged concentrations of PM_{10} in each metropolitan area. The data were initially screened as regards the availability (hourly-averaged data >65%). Time periods with data available for consecutive years were chosen. A distribution that best fits the PM_{10} day-averaged concentrations over the selected period was found for each station. We examined the applicability of the most common distributions for PM_{10} concentrations namely the lognormal and Weibull distributions (other distributions were also checked using statistical software). The lognormal distribution was found to best fit the frequency distributions of PM_{10} concentrations at the selected stations. The parameters of the lognormal distribution were calculated using the maximum likelihood-least squares method (Lu, 2002). The predicted concentrations were compared with the observed ones for the whole period and separately for each year. The results showing the geometric measured PM_{10} mean concentrations along with the minimum required emission reduction in order to meet the current AQS are presented in Table 1 for each station.

Table 1. Level of PM_{10} emissions reduction required for compliance with the 24-h average EU AQS at each monitoring station.

Monitoring Station (Type)	Geo. mean concentration (μg/m^3)	Required emission reduction (%)
Athens Metropolitan Area		
Aristotelous (TU)	54.32	40.16
Marousi (TU)	47.59	41.24
Pireaus (TU)	47.28	35.47
Lykovrisi (BS)	56.38	45.82
Thrakomakedones (BS)	29.73	3.75
Zografou (BS)	31.83	4.89
Agia Paraskevi (BS)	35.10	15.14
Goudi (TU)*	38.07	26.31
Thessaloniki Metropolitan Area		
Agia Sofia (TU)*	60.00	47.96
Kordelio (IU)	62.84	52.15
Kalamaria (TS)*	48.57	24.64
Panorama (BS)*	32.09	4.15
Sindos (IU)	48.68	35.02
Greater Area of Volos		
Volos (TU)	47.94	35.19

* data available for less than 5 consecutive years
B: background, I: industrial, T: traffic, U: urban, S: suburban

The minimum reduction required in order to meet the AQS at the areas of interest ranges from approximately 35 to 46% and from 4% to 15% for traffic and background stations in the AMA (Lykovrisi station was accounted for as traffic station). Reductions in the range of 35% for background and 52% for industrial suburban areas in TMA are also required. Finally, reductions of 35% are required for the GVA.

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