

# A methodological approach for evaluating the contribution of coal-fired power plant to atmospheric PM<sub>10</sub> concentrations using PMF and CMB receptor models

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The evaluation of the contribution of large coal-fired thermo-electrical power plant to atmospheric particulate matter (PM) concentrations is important for evaluation of risks to human health and potential influence on climate. The application of receptor models, based on chemical composition of PM, is not straightforward because the chemical profile of this kind of source is generally loaded with Si and Al and it is collinear with the profile of crustal particles (Bi *et al*, 2007).

In this work a methodology, based on Positive Matrix Factorization (PMF) receptor model and Si/Al diagnostic ratio, has been developed to discriminate the coal-fired power plant contribution from the crustal contribution. Measurements were taken in six different campaigns from February 2010 to August 2014, collecting in total 347 PM<sub>10</sub> daily samples at three sites having different characteristics: urban, urban background, and rural sites. These were located between 2.8 and 5.8 km from the Torrevadalia Nord power plant (indicated as TVN). The area studied was in the municipality of Civitavecchia in Central Italy. PM<sub>10</sub> samples were collected simultaneously on quartz and polycarbonate substrates. Quartz filters were used for determination of OC/EC concentrations by thermo-optical method (Sunset instrument, NIOSH 5040 method). Polycarbonate filters were used for the determination of water soluble ions concentrations (NH<sub>4</sub><sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>2+</sup>, SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>), using high performances ion chromatography (HPIC), and of main metals concentrations (Si, Al, Ti, V, Mn, Fe, Ni, Cu, Zn, Br), using Energy Dispersive X-ray Fluorescence (ED-XRF).

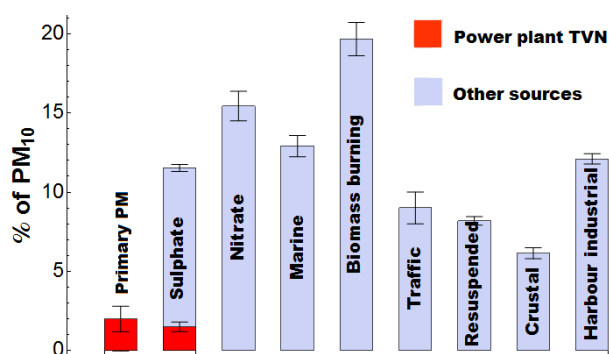


Figure 1. The relative contributions of the different sources to PM<sub>10</sub> concentrations.

Nine sources were identified using PMF5.0 model and their contributions are shown in Figure 1. Results showed an average primary contribution of the power plant of 2% ( $\pm 0.8\%$ ) in the studied area, with limited differences at the three sites analysed.

The robustness of the methodology was tested inter-comparing the results obtained with two other independent evaluations of TVN power contribution: the first using the Chemical Mass Balance (CMB) receptor model and the second correlating the daily Si-Al factor/source contributions of PMF with wind directions and CALPUFF/CALMET dispersion model results. Results showed a good comparability within experimental uncertainties. The contribution of the power plant to secondary ammonium sulphate was investigated using an approach that integrates dispersion model and receptor models results (PMF and CMB). The contribution of the coal-fired power plant to secondary ammonium sulphate in PM<sub>10</sub> were between 1.2% and 1.8% of PM<sub>10</sub> at the three sites with an average of 1.5% of PM<sub>10</sub> ( $\pm 0.3\%$ ).

The other sources apportioned were marine, nitrate, sulphate, crustal, road traffic, resuspended dust, biomass burning, and harbour-industrial. The comparison between the source contributions estimated with PMF and CMB showed a good agreement for all the source with the exclusion of traffic source that was overestimated in CMB with respect to PMF and harbour-industrial that was underestimated by CMB with respect to PMF. Both receptor models were able to reconstruct measured PM<sub>10</sub> following the differences between the sites and the daily variability. However, not explained mass was negligible with PMF but more relevant (7.6% of PM<sub>10</sub>) for CMB.

The contributions for marine and secondary sulphate sources were also evaluated using a stoichiometric approach. Marine contribution was evaluated as  $Cl^- + 1.4468Na^+$  (Contini *et al*, 2010) and secondary sulphate as the sum  $nss-SO_4^{2-} + NH_4^+$  where  $nss-SO_4^{2-} = SO_4^{2-} - 0.25Na^+$ . The estimates obtained with receptor models and stoichiometric calculations were comparable within the uncertainties with small differences observed at the three sites.

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