



Extended chemical speciation and source apportionment of PM_{2.5} at two sites in NE Italy

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Despite decades of EU air-quality policies and sector-specific emission controls, Northern Italy remains a European hotspot for PM pollution. With the forthcoming revision of the Ambient Air Quality Directive expected to tighten limit values, regions already close to (or exceeding) current thresholds will face an even greater compliance challenge. This study characterises the chemical composition and major contributing sources of PM_{2.5} at two sites in NE Italy: Belluno (Alpine valley) and Conegliano (Po Valley foothills).

A total 266 daily samples were collected during 2023. Comprehensive chemical speciation was performed, including elemental and organic carbon, major inorganic ions, major and trace elements, carboxylic acids, monosaccharides, alcohol-sugars, anhydrosugars, and benzothiazoles. These compounds serve as tracers of specific urban and regional emission sources, such as secondary aerosol formation, biomass burning, biogenic emissions, and traffic-related sources. In addition, a suite of organophosphate flame retardants (OFRs) was quantified.

PM_{2.5} mass closure was achieved, supporting the robustness of the chemical dataset. Source contributions were resolved through positive matrix factorization (PMF), complemented by post-processing analyses to better investigate local and regional influences. Results highlight differences between the two sites, reflecting their distinct geographical and meteorological settings. At Belluno, residential biomass burning emerges as a dominant PM_{2.5} source during the cold season, with pronounced wintertime increases associated with persistent thermal inversions and limited atmospheric dispersion. In Conegliano, PM_{2.5} shows a strong contribution from secondary aerosol formation and regional transport consistent with Po Valley influence. Traffic, biogenic aerosol, and resuspended dust contribute to a lesser yet non-negligible extent at both locations. An OFRs-related factor grouping most flame retardants was identified but having negligible influence on PM_{2.5} mass. Overall, the study provides insight into the role of local versus regional sources and meteorological controls on PM_{2.5} pollution in different sites across NE Italy, offering valuable information to support targeted mitigation strategies in both mountain and

lowland environments.

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