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Editorial

Special Issue Sources and Composition of Ambient Particulate Matter

Manousos-Ioannis Manousakas

Laboratory of Atmospheric Chemistry, Paul Scherrer Institute (PSI), 5232 Villigen, Switzerland; manousos.manousakas@psi.ch

1. Introduction

Research related to ambient particulate matter (PM) remains very relative today due to the adverse effects PM have on human health. PM are pollutants with varying chemical compositions and may originate from many different emission sources, which directly affects their toxicity. To formulate effective control and mitigation strategies, it is necessary to identify PM sources and estimate their influence on ambient PM concentration, a process that is known as source apportionment (SA). Depending on the geographical location and characteristics of an area, many anthropogenic and natural sources may contribute to PM concentration levels, such as dust resuspension, sea salt, traffic, secondary aerosol formation (both organic and inorganic), industrial emissions, ship emissions, biomass burning, power plant emissions, etc.

Different methodological approaches have been used over recent years to study the aforementioned topics, but some scientific challenges remain, mainly related to the subjects of real-time chemical analysis and SA, uncertainty estimation of SA results, and analytical optimization for PM samples. Additionally, there are areas in the world for which results regarding the composition and sources of PM are still scarce.

This Special Issue's target was to include studies on all aspects of PM chemical characterization and source apportionment regarding the inorganic and/or organic fraction of PM.

2. Results

This special issue includes 14 published studies referring to different regions around the world: Europe (seven), Asia (two), N. America (two), S. America (one), Africa (one), and Antarctica (one). The wide variety of areas included in the issue provide a good overview of particulate-related pollution worldwide. Even though the classification is not always easy as the studies discuss more than one subject, the publications of the issue can be divided into two sub-groups: source apportionment or contributions of specific sources to PM (nine papers), and composition, characterization, and characteristics of PM (five papers).

The first sub-group includes nine papers. In the study entitled "Contribution of Volcanic and Fumarolic Emission to the Aerosol in Marine Atmosphere in the Central Mediterranean Sea: Results from Med-Oceanor 2017 Cruise Campaign", the authors Moretti et al. [1] studied the contribution of the geogenic sources volcanoes and fumaroles to the aerosol in marine atmosphere in the central Mediterranean basin. The study was carried out in the framework of the Med-Oceanor measurement program and aimed in assessing the impact to the aerosol of the most important Mediterranean volcanoes (Mount Etna, Stromboli Island, and Marsili Seamount) and solfatara areas (Phlegraean Fields complex, Volcano Islands, Ischia Island, and Panarea submarine fumarole). Using factor analysis and SEM/EDX (Scanning Electron Microscopy with Energy Dispersive X-Ray Analysis) analysis for the source apportionment, anthropogenic and natural sources

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including shipping emissions, volcanic and fumarolic load, as well as sea spray were identified as the main factors affecting aerosol levels in the study area.

In another study that took place in Patra, Greece with the title "Source Apportionment of Fine Organic and Inorganic Atmospheric Aerosol in an Urban Background Area in Greece", the authors Manousakas et al. [2] identified and quantified the contributions to both the inorganic and the organic fractions of PM in the area. To meet that goal, both on- and off-line techniques were used, including elemental composition, organic and elemental carbon (OC and EC) measurements, and high-resolution Aerosol Mass Spectrometry (AMS) from different techniques. The results of the two methods were synthesized, showcasing the complementarity of the two methodologies for fine PM source identification. The synthesis suggests that the contribution of biomass burning is quite robust, but that the exhaust traffic emissions are not due to local sources and may also include secondary OA from other sources.

In a publication regarding the sources of total suspended particulate (TSP) in Antarctic, "Local and Remote Sources of Airborne Suspended Particulate Matter in the Antarctic Region", the authors Marina-Montes et al. [3] identified a potentially significant role of terrestrial inputs, marine environments, and biological inputs. Air mass back trajectories were used to confirm the elemental source. These trajectories revealed that both crustal and marine inputs occurred following different pathways and were influenced by the Antarctic Circumpolar pattern.

Yoon et al. [4], in their publication "Fine and Coarse Carbonaceous Aerosol in Houston, TX, during DISCOVER-AQ", investigated the major sources and trends of particulate pollution in Houston. Total suspended particulate (TSP) and fine particulate matter ($PM_{2.5}$) samples were collected and analyzed. Characterization of organic carbon (OC) and elemental carbon (EC) combined with real-time black carbon (BC) concentration provided insight into the temporal trends of $PM_{2.5}$ and coarse PM in Houston in 2013. Lachatre et al. [5], "Air Quality Degradation by Mineral Dust over Beijing, Chengdu and Shanghai Chinese Megacities", quantified the degradation of air quality by dust over Beijing, Chengdu and Shanghai megacities using the three dimensions (3D) chemistry transport model CHIMERE, which simulates dust emission and transport online. According to their findings, annual dust contributions to the PM_{10} budget over Beijing, Chengdu and Shanghai were evaluated respectively as 6.6%, 9.5%, and 9.3%, while they estimated that dust outbreaks largely contribute to poor air quality events during springtime.

In a study conducted in Sofia, Bulgaria, Hristova et al. [6] identified the source contributions to PM_{10} during the period January 2019–January 2020. The results from the source apportionment study showed that the resuspension factor is the main contributor to the total PM_{10} mass (25%), followed by biomass burning (23%), mixed SO_4^{2-} (19%), secondary (16%), traffic (9%), industry (4%), nitrate rich (4%), and fuel oil burning (0.4%) in Sofia.

Lonati et al. [7] performed air quality modeling at the very local scale, within the urban area of the Milan city center in Italy, is performed through a hybrid modeling system (HMS) that combines the CAMx Eulerian model with AUSTAL2000 Lagrangian model. Results show that the outcome of the Eulerian model at the local scale is only representative of a background level, similar to the Lagrangian model's outcome for the green area receptor, but fails to reproduce concentration gradients and hot-spots, driven by local-source emissions.

In another interesting study that took place in Dakar, Senegal, "Source Apportionment and Assessment of Air Quality Index of $PM_{2.5–10}$ and $PM_{2.5}$ in at Two Different Sites in Urban Background Area in Senegal", Kebe et al. [8] have quantified $PM_{2.5}$ and PM_{coarse} sources in the area using Positive Matrix Factorization (PMF), and specifically the version of the Enviromental Protection Agency of USA (US EPA), the PMF 5. Four PM sources were identified: industrial emissions, mineral dust, traffic emissions, and sea salt/secondary sulfates. The study showcased the importance of natural sources such as dust resuspension in countries located near to the arid regions of Africa.

In the final study of this sub-group, "First-Time Source Apportionment Analysis of Deposited Particulate Matter from a Moss Biomonitoring Study in Northern Greece", Betsou et al. [9] have moss samples as biomonitors of deposited PM. A total of one hundred and five samples, mainly of the Hypnum cupressiforme Hedw moss species, were collected from the Northern Greece during 2015–2016, which also included samples from the metalliferous area of Skouries. Using the PMF model, five sources were identified in the region: soil dust, aged sea salt, road dust, lignite power plants, and an Mn-rich source.

The second sub-group includes five papers. In the study of Cui et al. [10], "Characteristics of black carbon particle-bound polycyclic aromatic hydrocarbons in two sites of Nanjing and Shanghai, China", the sources of PAHs (Polycyclic aromatic hydrocarbons) and refractory black carbon (rBC) were explored. This work, for the first time, investigated exclusively the rBC-bound PAH properties by using a laser-only Aerodyne soot-particle aerosol mass spectrometer (SP-AMS). Two datasets were used from urban Shanghai during the fall of 2018 and in suburban Nanjing during the winter of 2017, respectively. A multilinear regression algorithm combined with PMF analyses on sources of PAHs revealed that the industry emissions contributed the majority of PAHs in Nanjing (~80%), while traffic emissions dominated PAHs in Shanghai (~70%).

In the study of Popovicheva et al. [11], "Functional factors of biomass burning contribution to spring aerosol composition in a megacity: Combined FTIR-PCA analyses", the authors used Principal Component Analysis (PCA) on infrared Fourier transmission (FTIR) spectroscopy data to estimate sources of aerosols in Moscow megacity in the spring of 2017. Principal component loadings of 58%, 21%, and 11% of variability reveal the functional factors of transport, biomass burning, biogenic, dust, and secondary aerosol spring source impacts. Caumo et al. [12], in their study "Variation of the distribution of atmospheric n-alkanes emitted by different fuels' combustion", presented the emission profiles of n-alkanes for different vehicular sources in two Brazilian São Paulo and Salvador using PCA. According to the analysis, the principal factors were attributed to mixed sources and to bus emissions. Pateraki et al. [13], "Differentiation of the Athens Fine PM Profile during Economic Recession (March of 2008 Versus March of 2013): Impact of Changes in Anthropogenic Emissions and the Associated Health Effect" evaluated the impact of the anthropogenic contribution to the fine PM chemical profile in Athens, Greece. They concluded that although the monitoring location was traffic-impacted, the heating sector, from both wood-burning and fossil fuel, proved to be the driving force for the configuration of the obtained PM picture.

In the last paper of the collection by Vinson et al. [14], "Seasonal Variation in the Chemical Composition and Oxidative Potential of $PM_{2.5}$", the purpose of this study was to analyze and compare the oxidative potential and elemental composition of $PM_{2.5}$ collected along two highways in central Oregon, USA in the winter (January) and summer (July–August). The oxidative potential (nM DTT consumed/μg $PM_{2.5}$/min) differed between seasons with summer samples having nearly a two-fold increase when compared to the winter. Significant negative correlations were observed between DTT consumption and several elements as well as with $PM_{2.5}$ mass, but the findings were dependent on if the data was normalized by $PM_{2.5}$ mass.

3. Conclusions

The studies in the collection can be divided into two sub-groups: source apportionment or contributions of specific sources to PM (nine papers), and composition, characterization, and characteristics of PM (five papers). All of the published studies in the first sub-group provide valuable information about PM sources in different regions worldwide and they showcase the importance and great relevance of source apportionment studies even today. Even though specific tools are preferred for such studies, such as PMF, various other tools that can be used that are described in the collection.

The studies from the second sub-group focus on certain chemical PM species and report PM's chemical characteristics in different areas and PM originating from specific sources.

The entire collection of studies provided valuable insights on PM chemical characterization and source apportionment regarding the inorganic and/or organic fraction of PM.

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