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Editorial

Urban Atmospheric Aerosols: Sources, Analysis, and Effects

Regina M. B. O. Duarte * and Armando C. Duarte

Department of Chemistry and CESAM—Centre for Environmental and Marine Studies, University of Aveiro, 3810-193 Aveiro, Portugal; aduarte@ua.pt

* Correspondence: regina.duarte@ua.pt

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Atmospheric fine particulate matter ($PM_{2.5}$, aerodynamic diameter less than 2.5 μm) has profound effects on radiative climate forcing, atmospheric chemistry, air quality and visibility, and human health [1,2]. $PM_{2.5}$ can be directly emitted into the atmosphere (primary aerosols) from a diversity of natural and anthropogenic sources, including biomass burning, the incomplete combustion of fossil fuels, volcanic eruptions, and wind-driven or traffic-related suspension of road, soil, and mineral dust, sea salt, and biological materials [1]. Nonetheless, $PM_{2.5}$ can be also formed in the atmosphere (secondary aerosols) through gas-to-particle conversion processes of gaseous species (i.e., nucleation, condensation, and heterogeneous and multiphase chemical reactions) [1,3]. Furthermore, primary and secondary aerosols may undergo chemical and physical transformations, being subjected to transport, cloud processing, and removal from the atmosphere [4]. This multitude of emission sources and formation/processing mechanisms contribute to the diversity and complexity of the chemical composition and physical properties (i.e., concentration, size distribution, and surface area) of atmospheric aerosols, which in turn influences the climate and health effects of atmospheric fine air particle, further adding a layer of complexity. Indeed, the physical and chemical characterization of $PM_{2.5}$, its source apportionment, and the assessment of the magnitude and distribution of $PM_{2.5}$ emissions is crucial for establishing effective fine particulate matter regulations and assessing the associated risks to human health.

Due to ever increasing urbanization, urban areas are a very special case as far as $PM_{2.5}$ concentrations, composition, sources, and health effects are concerned. A recent study conducted in five major cities (Athens and Paris in Europe, Pittsburgh and Los Angeles in the United States, and Mexico City in Central America) showed that most of the fine particulate matter (PM_1 or $PM_{2.5}$) is secondary (between 50% and 75% of aerosol mass load) [5]. The secondary components include sulfates and ammonium nitrate, but also oxidized organic compounds, whereas the major primary components are elemental (or black) carbon, metal oxides and crustal material, and fresh organic particulate matter. According to Pandis et al. [5], the importance of local sources is also quite different depending on the studied aerosol chemical component. For primary components such as elemental carbon, the local sources dominate; however, the situation is very different for secondary components, with most of the secondary material being due to either medium- or long-range sources [5]. Under this intricate scenario, knowledge of the detailed chemical composition, physical properties, and sources of fine particulate matter is crucial for assessing and managing the air quality surrounding large urban centers of both developed and developing countries. Nowadays, it is also well established that biological responses to $PM_{2.5}$ go beyond the particulate matter mass [6], and that additional air quality metrics (e.g., black carbon, secondary organic and inorganic aerosols) may be valuable in evaluating

the health risks of $PM_{2.5}$ at urban locations (e.g., [7]). Furthermore, understanding how outdoor $PM_{2.5}$ in urban areas affects the air quality of indoor environments in urban buildings and houses is also essential for assessing the potential health effects on residents [8,9]. Hence, much work is still needed to enhance our understanding of the chemical composition, size distribution, source apportionment, and indoor–outdoor relationships of $PM_{2.5}$ in urban areas and their health consequences upon exposure. Additional studies are also necessary to establish a more comprehensive understanding of how emission reduction measures will affect the levels and characteristics of $PM_{2.5}$ at urban locations.

The Special Issue "Urban Atmospheric Aerosols: Sources, Analysis, and Effects" is motivated by the need to address some important aspects concerning the chemical characteristics, optical properties, size-distribution, sources, and potential health effects of urban air particles. It comprises seven peer-reviewed, open access articles spanning the main topics of the field. For example, Hussein et al. [10] explore the temporal variability (diurnal, weekly, and seasonal) of particle number size distribution in the city of Amman (Jordan), as an example of an urban Middle Eastern environment. This study shows different seasonal variations for the submicron and coarse mode particle number concentrations. The authors also suggest the contribution of new particle formation for the submicron aerosols fraction, whereas sand and dust storms are the most important sources of coarse mode aerosols. These data highlight that the urban Middle Eastern region under investigation is exposed to the impacts of aerosols from various sources, which could become a serious health hazard if persistent for long periods of time. In another study, Li et al. [11] address the impacts of emission reduction measures on the characteristics and sources of trace elements in $PM_{2.5}$ at urban and suburban areas of Beijing, both before and after the 2014 Asia-Pacific Economic Cooperation (APEC) summit, which was held in Beijing. According to the authors, the air quality improved during APEC, with toxic elements, such as vanadium (V), chromium (Cr), manganese (Mn), arsenic (As), cadmium (Cd), and lead (Pb), decreasing more than 40% due to the emission regulations. Li et al. [11] highlight that future control efforts for toxic elements in megacities, such as Beijing, should focus on coal and oil combustion as well as on traffic emissions. Nevertheless, assessing the potential environmental exposure effects to atmospheric pollution (outdoor and indoor) is also important at locations other than megacities. In the study of Moreda-Piñeiro et al. [12], the authors assess the levels of particle-bound mercury (PHg) in PM_{10} (particulate matter with aerodynamic diameter less than 10 μm) at several sites (industrial, urban, and suburban) of an Atlantic coastal European region (i.e., the northwest of Spain) over 13 months. This study shows that the levels of PHg varied between 1.5–30.8, 1.5–75.3, and 2.27–33.7 pg m^{-3} at urban, suburban, and industrial sites, respectively. Data analysis also suggested an anthropogenic origin of PHg at the urban site, whereas biomass burning was likely to be the main source of PHg at the suburban site [12]. A sea salt and crustal/anthropogenic origin of PHg is suggested at the industrial site [12]. A toxicity estimate of PHg, using hazard quotient, suggested no non-carcinogenic risk for adults at the studied sites [12]. On the other hand, the preliminary study of Vicente et al. [13] provides a first insight into the occurrence of plasticizers and polycyclic aromatic hydrocarbons (PAHs) in PM_{10} from resuspended dust samples in Spanish households. The authors suggest that exposure to plasticizers and PAHs through the ingestion route poses much higher risks as compared to inhalation and dermal contact, which is of particular concern for infants due to their higher dust intake via hand-to-mouth activities. For the sake of easier comparison between different locations/houses, the authors also recommend the development of standard operational procedures for household dust sampling and analysis [13].

In the context of atmospheric pollution and global climate change, another important aspect is the need to unravel the chemical characteristics of atmospheric air particulate matter. Among the various $PM_{2.5}$ components, the water-soluble organic nitrogen (WSON) is the least studied aerosol component, although its role in secondary organic aerosol formation and its toxicity (e.g., [14] and references therein) has long been recognized. In this regard, the concentration of the WSON, with a particular focus on its seasonal variations and potential sources, is highlighted in the study of Chen et al. [15], which was carried out in urban Yangzhou (eastern China). This study shows that the annual mean WSON concentration (1.71 ± 1.08 μg m^{-3}) in Yangzhou was much higher than those in Japan, Greece,

and Florida (USA). It is also shown that the WSON concentrations had no significant seasonal and monthly variation; however, the WSON-to-total nitrogen mass ratios were much higher in summer and autumn than in winter and spring. The authors concluded that secondary formation is an important source of aerosol WSON in Yangzhou.

An additional approach to monitoring air pollution in urban and heavily industrialized areas is the consideration of aerosol optical depth (AOD), which measures the light extinction by aerosol scattering and absorption in the atmospheric column. Xue et al. [16] applied AOD data acquired from Moderate Resolution Imaging Spectroradiometer (MODIS) to assess whether correlations could be established between AOD and urban development, construction factors, and geographical environment factors in the Shandong Province over a 10-year timeframe (2007 to 2017). It was concluded that the introduction of targeted environmental protection policies was effective in alleviating pollution-related problems in the process of urbanization. Nonetheless, proper sampling of satellite AOD data is extremely important for a correct characterization of aerosol properties and air pollution over the areas of interest. Tian and Gao [17] address this challenge by assessing the accuracy of Terra-MODIS AOD retrieval products using the ground observations from twenty-three AErosol RObotic NETwork (AERONET) sites in heavy aerosol loading areas of Asia (including China, India, and Pakistan), the Middle East (including the United Arab Emirates, Bahrain, and Kuwait), and Northern Africa (including Egypt, Niger, Benin, Mali, and Nigeria). This study highlights the impact of land cover type and seasonal variation in the accuracy of the MODIS aerosol products and emphasizes the need for a suitable choice of the MODIS aerosol algorithms and products to assure a proper prediction of the air particles—AOD relationship.

In summary, the studies and the results discussed in this Special Issue will be of interest to the atmospheric research community, including those interested in air quality outdoors and indoors, visibility, the toxicity, composition, and sources of air particles, atmospheric chemistry, as well as global climate modelers. Finally, it is expected that the research presented here will inspire new research questions and hypotheses, which will help to untangle the strong connections between air particles and their impact on atmospheric chemistry, climate, and human health.

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Conflicts of Interest: The authors declare no conflict of interest.

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