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Editorial

Ambient Aerosol Measurements in Different Environments

Aikaterini Bougiatioti [1,*] and Evangelia Kostenidou [2]

[1] Institute for Environmental Research & Sustainable Development, National Observatory of Athens, I. Metaxa & Vas. Pavlou, GR-15236 Palea Penteli, Greece
[2] Laboratoire Chimie Environnement, Aix-Marseille Université, CNRS, 13331 Marseille, France; evangelia.kostenidou@univ-amu.fr
* Correspondence: abougiat@noa.gr

Particulate matter (PM) in the atmosphere has diverse natural and anthropogenic sources, and is a complex, heterogeneous mixture. Its size and chemical composition can change in time and space, depending on emission sources and atmospheric and meteorological conditions. Depending on the environment in question, aerosol chemical composition, size, shape and vertical distribution may vary considerably. The *Atmosphere* Special Issue entitled, "Ambient Aerosol Measurements in Different Environments", consists of eight original publications. The papers span a wide range of themes, including in-situ observations from all over the world, comprising China [1], the Philippines [2], Europe [3,4] and the Middle East [5,6], but they also consider instrumentation [7] and modeling studies [8]. This editorial provides highlights of these interesting publications and presents them in the broader context of atmospheric chemistry and physics.

The Eastern Mediterranean, and even more the Middle East, is an area highly influenced by mineral dust emissions. Since the World Health Organization has a daily $PM_{2.5}$ 24-h guideline limit of 25 μg m^{-3}, it is obvious that the monitoring of ambient particulate matter in such environments is crucial. Khader and Martin [5] deployed three low-cost, locally calibrated particulate monitors at different elevations and source areas throughout the city of Nablus in the Northern West Bank, Palestine, for three-week periods during spring in 2018. The average concentrations were well above the WHO guidelines for $PM_{2.5}$ 72% to 96% of the time, while, for PM_{10} at the downtown location (DT), the average daily exceedances occurred 64% of the time, and less than 30% of the time at the other two valley sites. Both $PM_{2.5}$ and PM_{10} were often two to three times higher at the DT location due to enhanced emission sources, while peak events with enhanced levels of mineral dust from dust storms during spring were found to exacerbate the PM concentrations. The use of such a sensor network could be used to identify area-specific pollutant levels, local sources, and possibly provide remediation recommendations and warnings for the local population.

Likewise demonstrating possible sources of poor air quality in the area, Hussein et al. [6] mapped size-fractionated particulate matter, measured with portable instruments, in the two most populated cities in Jordan, namely Amman and Zarqa. Compared to the WHO limit, PM_{10} concentrations in Amman were close to the limit, whereas $PM_{2.5}$ concentrations were often higher. This work demonstrated that ultrafine particle (UFP) number concentrations, $PM_{2.5}$, PM_{10}, and black carbon levels were greater near roads and industrial areas, while on-road observations revealed PM mean concentrations exceeding 50 μg m^{-3} and 100 μg m^{-3} (for $PM_{2.5}$ and PM_{10}, respectively). On the other hand, when driving through the city, mean $PM_{2.5}$ and PM_{10} were 126 μg m^{-3} and 238 μg m^{-3}, respectively. The topography of the city of Amman—with downtown being the lowest point between seven hills, thus limiting ventilation, as well as enhanced emissions from traffic congestion, plenty of restaurants (grilling) and coffee shops offering water pipe smoking that requires coal burning—further exacerbates the air quality problem, and denotes that exposure is much higher than predicted based on ambient air quality monitoring at stationary sites. As Zarqa is a center of industrial activities, with landfill areas close by, mean concentrations were

Citation: Bougiatioti, A.; Kostenidou, E. Ambient Aerosol Measurements in Different Environments. *Atmosphere* **2021**, *12*, 429. https://doi.org/10.3390/atmos12040429

Received: 20 March 2021
Accepted: 23 March 2021
Published: 26 March 2021

found to be 62 μg m^{-3} and ~113 μg m^{-3} (for $PM_{2.5}$ and PM_{10}, respectively). Therefore, in Jordan, a large part of the population, especially in cities, is exposed to poor air quality which exceeds WHO standards.

In another study focusing on poor air quality related to traffic emissions in Manila, the Philippines, Madueño et al. [2] conducted an intensive measurement campaign in an urban street canyon in order to calculate the emission factors (EF) of the equivalent black carbon (BC) and particle number of the most commonly used vehicles. Results showed that emissions in Manila were dominated by ultrafine particles (UFPs), with BC emission accounting for up to 70% of the calculated PM_1 mass EF. These findings demonstrate that the population is exposed not only to high concentrations of UFPs but, also, to highly toxic ones. Furthermore, separate EFs were calculated according to vehicle category, and it was found that public utility jeepneys (PUJ) emit six to seven times more UFPs than light-duty vehicles, contributing to more than 60% of BC emissions in Manila. The presented results provide a framework for targeted traffic interventions in an effort to improve urban air quality in countries with a similar fleet comprised of old-technology vehicles.

Continuing on to another highly populated urban environment in the Eastern Mediterranean, the Greater Athens Area also often records pollution events which are greatly influenced by both local emission sources and by long-range transport, impacting 36% of the Greek population living within this area. Pateraki et al. [3] focus on $PM_{2.5}$ and PM_1-bound polycyclic aromatic hydrocarbons (PAHs) at three sites within the basin—urban background, roadside, and coastal background conditions. They found that pollution events were a mixture of simultaneous exposure to a variety of pyrogenic and petrogenic sources, with the intensity of emissions and sampling location being critical for the recording of enhanced concentration levels. It was also found that for $PM_{2.5}$ mass load, the traffic input was the determinant factor, while for PAHs, the key parameter was the residential heating sector. Highlighting the importance of prevailing meteorological conditions, as well as characteristics of the air masses arriving to a receptor site from regional distances, especially for background locations, the coastal $PM_{2.5}$ were found to be more carcinogenic/mutagenic than the urban background environment within the basin.

As seen in the previous study, apart from traffic, residential activities that include combustion processes also lead to enhanced concentration levels. In their study, Sang-Arlt et al. [1] characterize near-source smoke emissions from household stove combustion in a rural area of South China, using seven typical biomass fuels. Carbonaceous material (organic and elemental carbon) was found to comprise the majority of the fine ($PM_{2.5}$) particle mass, with mass concentrations of particulate matter emitted from rice straw burning being the highest. Among the seven biomass fuels, bamboo exhibited the highest OC/PM_{10} and $OC/PM_{2.5}$ ratios, while Chinese fir had the lowest OC/PM_{10} ratio and peanut straw had the lowest $OC/OM_{2.5}$ ratio. The highest organic to elemental carbon ratios were also observed for straw, and the lowest for softwood and bamboo. Possible differences may arise from the burning process and burning products in the different burning stages, as well as from the influence of the fuel moisture content. This study highlights the emissions from biomass burning for cooking purposes in the area, which can be a significant source of particulate matter and relevant atmospheric pollutants.

Aerosol particles are both primarily emitted in the atmosphere and secondarily formed from atmospheric processing of organic and inorganic precursors, with the secondary organic aerosol (SOA) constituting a substantial fraction of the mass of submicron aerosol in populated areas around the world; this contributes to poor air quality and premature mortality [9]. In the first ambient oxidation flow reactor measurements in Europe, Ahlberg et al. [4] demonstrated that there was no increase in particle mass or number concentrations during the two months of the campaign, which was primarily attributed to limited gaseous precursor concentrations and, to a lesser extent, to a net particle mass loss of ~10%, correlated to ambient temperature and OH exposure. It was shown that, with ambient PM_1 concentrations in the order of 3 μg m^{-3}, one order of magnitude higher precursor concentrations would have been needed to form significant amounts of SOA in

the reactor. This finding, demonstrates that relatively low ambient aerosol levels and their processing can result in lower secondary mass concentrations.

Apart from the in-situ measurements, instrumental improvements are necessary to shed light in atmospheric aerosol pollution. In their study, Attoui and Kangasluoma [7] boost a commercial CPC by increasing the temperature between the saturator and the condenser, and use, for the first time, positively charged monomers and dimers, such as tetraheptylammonium bromide (THABr), tetrabutylammonium bromide (TBABr), and tetraethylammonium bromide (TEABr), dissolved in methanol or water–methanol mixtures. The detection efficacy in the sub 2 nm range is enhanced, and particles of THABr are activated at a temperature difference of 32 °C, while, with a 36 °C difference, a detectable signal is observed, even for the smallest ion used in the study (monomer of TEABr). There was no activation in the CPC for a temperature difference lower than 31 °C. Although the three ions are soluble in butanol, the fact that the tetra ethyl ammonium ion is activated with higher detection efficiency, whilst being more mobile (1.01 nm) than the lightest ion, suggests that the solubility in water of the particles or ions plays a major role. The results showed that significant advances can be made in terms of particle detection.

Last but not least, Joharestani et al. [8], in their modeling study, use 23 features, including satellite and meteorological data, ground-based $PM_{2.5}$, and geographical data, in order to accurately predict $PM_{2.5}$ concentrations in Tehran, the capital of Iran, where annual $PM_{2.5}$ concentrations significantly exceed the WHO limits. They do so by implementing Random forest (RF), extreme gradient boosting (XGBoost), and Deep learning machine learning (ML) approaches, using 37 air pollution monitoring sites within the city of Tehran. It was derived that, compared to RF and Deep learning methods, XGBoost achieved the best performance, with a very low computational time. All three machine learning approaches performed similarly when aerosol optical depth (AOD) was included or excluded. Based on feature importance ranking, some features were found to highly depend on others. It was concluded that, by using 8 to 12 features, such as PM2.5_lag1, day of year, wind speed, visibility, latitude, air pressure, dew point, PM2.5_lag2, and altitude, an acceptable performance of $R^2 = 0.79$ ($R = 0.888$), Mean Absolute Error = 10.20 $\mu g/m^3$, and Root Mean Square Error = 14 $\mu g/m^3$ was obtained. This study is the first to investigate the importance of different features of $PM_{2.5}$ prediction, and to show that some features are more important than other in specific study areas.

The Editors would firstly like to thank all the authors who kindly contributed their research, time and, knowledge to ensure the high quality of this special issue. The Editors would also like to express their gratitude to the *Atmosphere* journal team, including editors, reviewers, and the production team for their invaluable support and cooperation in the publication of the book.

Author Contributions: A.B. Writing-Original draft preparation, E.K. Writing-Reviewing and Editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

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

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