CIVIL AND ENVIRONMENTAL ENGINEERING

MUR DM 118 - Air pollutants measurement and assessment systems, focused on the urban FP and UFP analysis

Funded By	Dipartimento di Ingegneria dell'Ambiente, del Territorio e delle Infrastrutture [P.iva/CF:00518460019] MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584]
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Context of the research activity	The Ph.D. will have as its theme an in-depth study of methods for measuring and evaluating air compounds mass concentration finalized at analyzing the dynamics of fp and ufp in relation to meteo-climatic conditions, the presence of precursor gases, and changes in altitude. The analyses will be focused on urban areas, but should also extend to other critical conditions such as rural agricultural and natural alpine and coastal scenery. Progetto finanziato nell'ambito del PNRR - DM 118/2023 - CUP E14D23001710006
	Rapid urbanization and economic growth have prompted the intensive use of fossil fuels, increasing particulate concentrations FP and UFP (PM2.5 and PM1, atmospheric fine particles with an aerodynamic diameter less than 2.5 µm and 1 µm respectively), PM10, gases such as nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), ozone (O_3) and greenhouse gases, such as carbon dioxide (CO_2). Particulate matter plays a major role in public health, generating negative effects on organs such as lungs, heart, and brain. It also has a strong influence on climate change, inducing a warming effect on climate through solar and infrared radiation absorption. Environmental health studies usually use the mass concentration of fine particles (FP and UFP) as a base data to predict the health risks of particulate exposure, calculated with modeling-based forecasting methods. A large variety of models concerning atmospheric pollution is used, starting from small scale computational fluid dynamics (CFD) models, such as a street canyon, up to expanded geographic scales involving regional and hemispherical models for the pollutants with enough lifetime in the atmosphere.

Objectives	Although some of the techniques such as Eulerian approach or CFD modeling consider sophisticated 3D processes, most of the models are not able to estimate FP mass concentration independently from ground observations. Due to an increasing number of multidisciplinary researches on pollution assessment, the demand of FP/UFP measures is also increasing, requiring an ever-growing number of stations in order to provide input data for a finer-meshed network. The purpose of this PhD study is to design and realize a data acquisition system of atmospheric PM (UFP-PM1, FP-PM2.5, PM10), NO2, NH3, O3 ground mass concentrations together with meteorological variables suitable for urban areas; the metropolitan Turin area, one of the most critical European sites for air quality, will be analyzed as a case study. Taking advantage of the previous experiences developed at DIATI, a measurement system of the above listed parameters will be arranged, based on the adoption of the available certified instruments for fixed and mobile stations, as well as on the use of a low-cost sensors system to improve the number of data sources. Appropriate sensors network management procedures aimed to calibration and sensor performance monitoring, will also be needed, in order to guarantee the measurements significance. The sensors system check operations may also require the use of specific equipment to ensure high quality instrumentation mobility to be developed in the frame of the doctorate research. This approach based on a larger number of data sources is intended to make available to multidisciplinary studies improved long-term datasets generated by widespread measurements, thus suitable as input for urban area pollution modelling. Specific measurement campaigns aimed to high temporal resolution FP measurements by means of optical meters to correlate with meteo-climatic data will also be supported by the improved equipment mobility. The wide data availability can also provide better input feeding for the space/time analysis of FP and UFP concentrations as a function of the other air pollutants measurements, thus exploring the dynamics of primary and secondary particulate generation. During the PhD the integration of aerial and satellite drone measurements with ground-based measurements in the estimation of pollutants could also be examined. As far as drone aerial measurements are concerned, the mass concentration values of airborne particles resulting from ground systems and drone aerial systems can be directly compared: environmental conditions, investigation scales and flight altitude of the drone are different among urban, rural or natural scenarios. Concerning satellite data, indirect particulate matter estimation uses aerosol optical depth (AOD) to estimate FP and UFP ground concentration. A comparison among satellite data, ceilometer measurements (available at DIATI) and ground measurements system data could improve the correlation

	between AOD and FP measurements at ground level.

Skills and competencies for the development of the activity	Knowledge of environmental dynamics of airborne formation and removal in natural and anthropogenic scenarios, with specific reference to urban conditions. Knowledge of FP and UFP assessment and measurement criteria, of NOx, NO2, O3, etc. Acquired skills related to aerosol monitoring and/or measurement activities in different environmental scenarios and knowledge of fixed and mobile aerosol assessment equipment such as gravimetric meters, optical meters, sensors, fixed and portable analyzers.