

Low cost sensors network for PM and NO₂ urban monitoring: initial and ongoing calibration and management

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Urban areas are particularly vulnerable to elevated pollution levels due to a combination of emissions from traffic, heating, and industrial activities, as well as the high population density. The urban geometry, characterized by narrow and interconnected streets (Fellini et al., 2021), further contributes to the trapping of air pollutants. Among the primary pollutants in urban environments that pose significant health concerns are particulate matter (PM) and Nitrogen Oxides (NO_x), in particular Nitrogen Dioxide (NO₂). Both pollutants are a key factor that influences air quality and human health (Anenberg et al., 2022). In order to measure concentrations of these pollutants, the spatial and temporal resolution of the measurement are a key factor. Low-cost sensor (LCS) are gaining more and more interest as they can provide near-real-time observations, with high spatial and temporal resolution (Cavaliere et al., 2023). Calibrated LCS can be an effective tool in the assessment of exposure to air pollutants, as confirmed by (Aix et al., 2023). However, LCSs need special attention because they are strictly dependent on calibration.

Following a year of experimentation in collaboration with ENEA - Portici Research Centre, using two MoNiCa devices a calibration methodology was developed. Ten low-cost micro-sensor stations called MoNiCa were fixed to monitor PM and NO₂ in the city of Turin. The calibration involves the correlation, for the same period of time (two weeks), of the measurements of MoNiCa with the measurements performed by an optical aerosol spectrometer certified for air pollution monitoring (Palas Fidas 200S) for PM, and with the measurements of the analyser certified Envea AC32e for NO₂, at the fixed monitoring station of the Department of Environmental, Land and Infrastructure Engineering (DIATI), Polytechnic University of Turin.

The ten MoNiCa are placed in the city of Turin with the involvement of citizens, public and research institutions, and universities. In fact, the devices were placed on property balconies essentially respecting the following criteria: presence of high traffic roads, height of no more than 25m above street level, presence of power supply, and presence of internet connection. In

this regard, it is worth emphasising the necessary presence of the certified air quality monitoring stations in the area, in order to keep the accuracy of the measurements under control. In doing so, we were able to set up an initial, although small, monitoring network, which is keeping under control for the duration of the campaign through remote control of the instrumentation. A Python script was specially developed for direct data storage in order to have full real-time control of the stations.

Throughout the campaign, trends in the concentrations of the pollutants were consistent with the meteo-climatic (temperature and humidity), traffic and positioning (heights) characteristics: the differences in PM and NO₂ concentrations measured by MoNiCa are also reflected in the measurements of the certified instruments flanking them and are representative of the installation context. Finally, it is necessary to expand the network in number of devices in order to achieve a better resolution of the measurement, also for the purpose of future developments that may lead to a methodology for structuring a more robust monitoring network. As mentioned in (Cavaliere et al., 2023) LCS observations can be integrated into the current official regulatory networks, usually monitoring air quality at lower space and time resolution. Based on the research carried out, LCS proved to be a complementary technology to canonical instrumentation capable of meeting specific and research applications.

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